E/CONF.39/A/173
25 Oct.1962
ORIGINAL : FRANCAIS

CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : A. 5. 3

Italie

# LA MINE DE S. CATALDO EN SICILE : EXTRACTION ET ENRICHISSEMENT DE LA KAÏNITE

Par G. MARULLO,
Ingénieur,
Directeur de l'Institut de Recherche
"G. DONEGANI" de la Société Montecatini,
Milan, Italie

et I. VACCARI,
Ingénieur,
Directeur du Secteur Minier
de la Société Montecatini,
Milan, Italie

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

## NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

## Le mine de S. Cataldo en Sicile: extraction et enrichissement de la kainite

La recherche des sels potassiques dans la province de Caltanissetta en Sicile a été commencée par la Société Montecatini en 1952. L'étude géologique, effectuée dans la zone des permis de recherche, a démontré la probabilité de retrouver des gisements potassiques. La recherche fut intégrée avec l'exécution de 8 forages jusqu'à une profondité de 770 mètres. Avec ces travaux, on a constaté l'existence d'un gisement à une profondité de 150 à 600 m, long 3.000 m et large 900 m.

Le gisement, appelé "San Cataldo", appartient au Miocène et gît sur la formation "crayeux-sulfifère". Il comprend plusieurs couches de kainite ($KCl.MgSO_4.3H_2O$), jusqu'à une épaisseur de trente mètres, entre couches de sel gemme (NaCl). La réserve du gisement pour la partie explorée est évaluée en 46 millions de tonnes.

Pour la création de la mine, il a été nécessaire résoudre de graves problèmes dus au manque de main-d'oeuvre locale spécialisée et des services généraux. Ces problèmes seront traités après.

1) Exploitation du gisement

L'exploitation du gisement a été établie sur les méthodes les plus avancées de mécanisation qui existent à ce jour; ceci a exigé la solution de problèmes particuliers, par exemple celui de permettre un déplacement relativement facile, entre les différents niveaux de la mine, aux grandes machines requises pour l'exploitation. Dans l'ensemble, la préparation a requis l'excavation d'environ 20 km entre galeries, descentes, fours, etc.

L'exploitation est exécutée en 2 différentes couches. La première couche de 4 mètres est constituée de kainite riche (17% $K_2O$); elle est exploitée au moyen de perforateurs électriques et scrapers de 75 HP.

La deuxième couche est constituée de kainite à un titre moyen (13% $K_2O$), de l'épaisseur de 30 m; elle est exploitée au moyen de machines très modernes, uniques en Italie, qui exécutent le coupage, la perforation, le chargement et le transport du minerai abattu.

Ce matériel comprend :

Coupeuses (HP 105 - Poids Kg 16.000 chacune)
Perforateurs (HP 26 - Poids Kg 10.000 chacun)
Chargeuses (HP 34 - Poids Kg 12.000 chacune)
Chariots navette (HP 45 - Poids Kg 14.000 chacun)

Le minerai abattu, des deux couches, est convoyé alternativement au niveau +10 de la mine et delà, au moyen de transporteurs à courroie et à raclettes (longs en tout 1.100 m), envoyé à l'installation du premier concassage établi au même niveau. Cette installation comprend deux silos de la capacité de 300 tonnes chacun et deux concasseurs à marteaux chacun avec un moteur de 370 HP.

Les deux types de minerai kainitique sont concassés distinctement en morceaux de 150 mm et transporté au moyen d'une courroie transporteuse, longue 90 m, à la base du puits d'extraction, profond 420 m. D'ici le minerai est élevé automatiquement aux installations extérieures au moyen de skips de la portée de 5.5 t chacun. Tout le transport du minerai depuis le front d'abattage jusqu'à l'extérieur de la mine est fait automatiquement.

L'ensemble des machines décrites permet une extraction par jour de 3.000 t de minerai kainitique.

Les conditions à l'intérieur de la mine sont excellentes grâce à une ventilation très efficace (ventilateur de 700 HP pour 5.000 $m^3$/minute d'air).

2) Enrichissement du minerai brut

L'installation d'enrichissement du minerai kainitique est installée près du puits principal d'extraction; l'installation est reliée avec le puits au moyen d'une courroie transporteuse.

L'installation d'enrichissement occupe dans l'ensemble une superficie supérieure à 20.000 $m^2$ et comprend un bâtiment divisé en 3 sections; dans chaque section sont installées, en cascade, les machines nécessaires aux trois

opérations fondamentales de l'enrichissement, c'est-à-dire :

a) broyage à sec

b) broyage humide

c) flotation et séparation des solides des liquides

A l'extérieur du bâtiment sont installés les gros décanteurs et les réservoirs pour la saumure; à côté du bâtiment principal sont installés deux hangars de stockage du minerai et les différents bâtiments pour les services généraux (poste électrique, ateliers, laboratoire, etc).

Les trois opérations susdites se déroulent selon le cycle suivant :

a) Broyage à sec ou concassage secondaire

Le minerai extrait a déjà subi dans la mine un premier concassage à environ 150 mm; il passe en cascade à travers une série de 2 concasseurs à marteaux et 3 tamis vibrants et est réduit en morceaux de 4 mm. Une série égale est tenue en réserve. Le matériel comprend en outre des élévateurs et des transporteurs à chaîne du type Radler, ainsi qu'une installation de dépulvérisation qui maintient l'air ambiant sans poussière.

Les commandes électriques de cette section sont centralisées dans une cabine; à travers un cadre lumineux qui reproduit le cycle de travail, un seul opérateur réussit à suivre et à régler les opérations de chaque machine. Le potentiel de traitement de cette section est de 300-350 t/h, égal, c'est-à-dire, au potentiel d'extraction du minerai du sous-sol. L'opération est faite par deux équipes qui travaillent chacune 8 heures par jour.

b) Broyage humide

Dans cette section qui travaille 24 heures par jour, on exécute le broyage humide jusqu'à 0,6 mm du minerai provenant du broyage à sec. A cette valeur, les granules de kainite sont détachés des granules de chlorure de sodium.

En particulier, le minerai broyé à sec est classé avant à 0,6 mm au moyen d'aéro-cyclones séparant ainsi la fraction inférieure, déjà prête pour être envoyée à la flotation; la fraction supérieure est suspendue en saumure et envoyée à 2 broyeurs à barres, travaillant en cycle fermé avec deux classificateurs à spirale.

Le minerai, broyé humide, est réuni à la fraction fine séparée des susdits cyclones et envoyé à la flotation.

c) Flotation

Le minerai brut est constitué environ de 2/3 de kainite et le reste de chlorure de sodium et de substances argileuses, celles-ci en % du 0,5-1. Le minerai avant la flotation subit l'opération de débourbage (déslimage), conduite sur la pulpe provenant du broyage. Cette opération se fait par décantation différentielle et permet l'éloignement d'au moins le 60% des parcelles extrêmement fines de la boue et du sel. Ces parcelles fines nuisent sensiblement à la sélectivité de la flotation et élèvent considérablement la consommation des réactifs.

La pulpe du minerai débourbé, réglée à une concentration de sel environ à 30% en poids, est conditionnée avec un collecteur cationique, constitué par l'acétate d'une mélange d'amines aliphatiques ayant en moyenne 12 atomes de carbone, et successivement portée aux cellules de flotation, en ajoutant du cyclohexanol qui agit comme régulateur de la mousse. On ramasse la kainite dans les écumes tandis que le chlorure de sodium et les autres impuretés restent dans la pulpe des stériles (tailings). La flotation est faite en 4 batteries de cellules, mises en parallèle, ayant dans l'ensemble un volume de 60 $m^3$. Le rendement de la potasse est de l'ordre de 95-96% pour un titre dans le concentré aux environs du 17,5% de $K_2O$.

Les pulpes de la flotation sont épaissies en décanteurs (épaississeurs) continus, type Dorr, et ensuite envoyées aux filtres rotatifs continus et aux essoreuses (à axe horizontal, à débit continu) pour séparer les sels soli-

des des saumures. Les saumures troubles sont clarifiées en 3 gros décanteurs de 1000 $m^2$ chacun et envoyées dans 4 réservoirs de stockage de 1500 $m^3$ chacun; de ceux-ci la saumure revient dans le cycle.

Aussi pour les sections de broyage humide, flotation, décantation et filtrage, les commandes des appareils se trouvent dans des cabines d'où sont suivies et controlées les différentes phases de travail et le fonctionnement de chaque machine.

3) Ultérieur traitement

La kainite, enrichie et humide, passe directement des filtres et des essoreuses sur courroies transporteuses qui la convoient au magasin de stockage.

Automatiquement, du magasin la kainite est envoyée sur chariots d'un téléphérique (longueur 18 km, capacité 180 t/h) qui la transporte à l'usine de Campofranco où elle est transformée en sulfate potassique.

4) Formation du personnel

La possibilité de disposer de personnel qualifié constituait un élément important autant que le plan de la mine et le choix des moyens de travail. Il n'était pas possible de trouver des éléments déjà préparés techniquement dans la main-d'oeuvre locale parce qu'elle s'occupe d'agriculture avec des moyens limités et possède une instruction limitée; toutefois, on a réussi à l'utiliser.

On a choisi des jeunes qui, n'ayant aucune formation professionnelle, constituaient un terrain neuf pour la formation et l'acheminement aux fonctions qu'ils auraient eu dans le travail de la mine. Des cours ont été organisés pour les jeunes déjà sélectionnés par un premier examen d'aptitude. A ces cours d'une durée de 6 mois, outre les premiers éléments de base de culture, on a enseigné les notions techniques indispensables à la connaissance générale des machines et de l'outillage minier.

Pendant les cours, les aptitudes de chaque élément ont été déterminées afin

de diriger sa formation. En même temps, des exercices pratiques sur les machines et l'outillage ont été faits; dans cette période on est arrivé à la définitive sélection et assignation des devoirs de chaque élève.

De cette manière, a été formée la presque totalité de la main-d'oeuvre destinée à la conduction et à l'entretien des machines pour l'intérieur de la mine; ainsi on a eu un premier groupe d'environ 100 ouvriers spécialisés.

On peut affirmer, après une longue période d'observation, que la formation du personnel a correspondu aux exigences du travail; en effet après peu de mois d'exercice, les ouvriers avaient rejoint un degré de formation comparable à celui des collègues des modernes mines de sels potassiques du Nord Europe et des U.S.A. Ceci a été confirmé par le rendement élevé atteint, égal au delà de 25 tonnes de minerai extrait par ouvrier.

5) Oeuvres préalables

Le manque total d'habitations et de services généraux a rendu nécessaire des travaux préalables pour la mise en valeur du gisement minier.

Près de la mine, on a construit les habitations nécessaires à loger les techniciens et les ouvriers spécialisés dont on pouvait avoir un besoin immédiat.

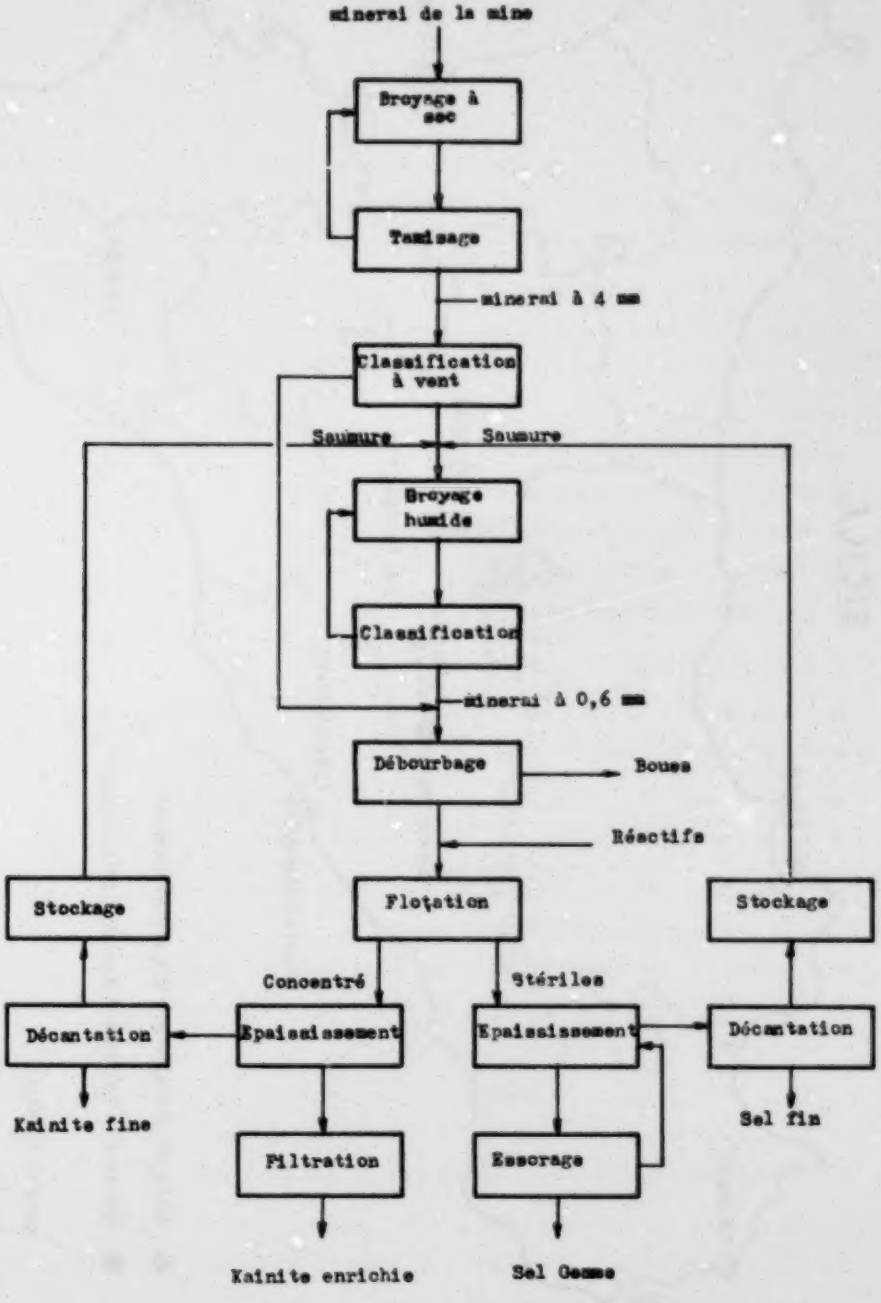
Le manque de cours d'eau à débit continu a rendu nécessaire la construction d'un bassin près des installations pour recueillir environ 250.000 mc d'eau nécessaires au traitement pendant les mois d'été. Une station de pompage sur le torrent "Gallodoro" alimente ce bassin durant les mois d'hiver au moyen d'une conduite longue environ 5 km.

Le manque d'un réseau routier pour le transport de la kainite enrichie a obligé la construction d'un téléphérique, long 18 km, reliant la mine à l'usine de Campofranco où la kainite est transformée en sulfate potassique.

En outre, il a été nécessaire créer aussi les services secondaires, par exemple les routes internes, l'aqueduc pour l'eau potable, les branchements électriques, les oeuvres sociales, etc.

La mine de S. Cataldo en Sicile

Enrichissement de la kainite



SICILE
PALERMO
MESSINA
TRAPANI
ENNA
Campofranco
S. Cataldo
CATANIA
CALTANISSETTA
AGRIGENTO
Porto Empedocle
SIRACUSA
RAGUSA
Mine et installation d'enrichissement
Usine de traitement des sels potassiques
Echelle 1:1000000
0 10 20 30 40 50 Km

8

A/173

1308 F - Oct. 1962 - 1,000

E/CONF.39/A/174
12 Nov.1962
ESPAÑOL
ORIGINAL : RUSO

CONFERENCIA DE LAS NACIONES UNIDAS
SOBRE LA APLICACION DE LA CIENCIA Y LA TECNOLOGIA
EN BENEFICIO DE LAS REGIONES MENOS DESARROLLADAS

Punto del programa : A.1.1

República Socialista
Soviética de Bielorrusia

# EMPLEO DEL LEVANTAMIENTO AEROFOTOGRAFICO PARA LA EXPLORACION Y VALORACION DE LOS RECURSOS NATURALES

Por V.N. BRUJANOV,
Ingeniero geólogo

Las monografías presentadas en la Conferencia de las Naciones Unidas sobre la Aplicación de la Ciencia y la Tecnología en Beneficio de las Regiones Menos Desarrolladas constituyen documentos de trabajo de dicha Conferencia. Se publican tal como han sido presentadadas por los colaboradores y los puntos de vista expresados en ellas corresponden a los colaboradores. (Veánse notas al dorso.)

## NOTAS

1. Las monografías seleccionadas para las Sesiones Generales serán distribuidas en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

2. Las monografías seleccionadas para las Sesiones Especiales serán distribuidas en la Conferencia únicamente en uno de los idiomas oficiales antes indicados.

3. Los resúmenes de las monografías presentadas por los colaboradores serán distribuidos en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

4. No se procederá a la distribución general de las monografías y resúmenes con antelación a la Conferencia. Unicamente serán publicadas en cantidades limitadas con antelación a la Conferencia para uso exclusivo de las delegaciones de los gobiernos participantes y de otros participantes autorizados. La publicación con posterioridad a la Conferencia y la distribución general de las actas y debates de la Conferencia seguirán las prácticas de las Naciones Unidas establecidds por ia Junta de Publicaciones de las Naciones Unidas.

# EMPLEO DEL LEVANTAMIENTO AEROFOTOGRAFICO PARA LA EXPLORACION Y VALORACION DE LOS RECURSOS NATURALES

Por V.N. ERUJANOV, ingeniero geólogo

El levantamiento aerofotográfico empleado en la URSS para explorar los recursos naturales, sobre todo en las regiones menos investigadas, eleva considerablemente la calidad, reduce la duración y el coste de los trabajos.Los materiales del levantamiento aerofotográfico adquieren un valor especial para explorar las regiones poco accesibles como vastos desiertos, sistemas montañosos, macisos de bosques tropicales y subtropicales, etc.

a) Trabajos geológicos

Los materiales del levantamiento aerofotográfico tienen un gran valor para las investigaciones geológicas.

Para los fines de la confección de mapas geológicos están elaborados los parámetros razonables del levantamiento aéreo, que permiten obtener fotografías aéreas que poseen las mejores propiedades de descifrado. Al determinar los parámetros del levantamiento aerofotográfico se toman en cuenta las particularidades de paisaje del territorio, así como la escala y destinación de los trabajos geológicos.La escala del levantamiento aerofotográfico se escoge de acuerdo con la envergadura de las investigaciones geológicas y complejidad de la estructura geológica. Para dibujar los mapas geológicos de la escala 1:200.000, la escala de las fotografías aéreas varía de 1:25.000 a 1:50.000, y dibujando los mapos de la escala 1:50.000, ésta varía de 1:10.000 a 1:25.000.

El tiempo para sacar las fotografías aéreas se elige durante la temporada partiendo de las particularidades del paisaje (presencia de los contrastes más acusados en el humedecimiento da las rocas, de la flora, número de días claros, estado de la atmósfera, etc.).

La hora de día para sacar fotografías aéreas y la selección de la distancia focal de la máquina fotográfica aérea se determinan por las formas del terreno. En las regiones llanas, para destacar las formas del terreno, las fotografías aéreas se sacan en las primeras horas matutinas o en horas vespertinas empleando las máquinas fotográficas de corta distancia focal (f = 100); en las regiones montañosas, en las horas próximas al mediodía, con máquina de una distancia focal de 200 y más.

Para localizar las regiones con rocas de colares diferentes se emplea una película aerofotográfica en colores, de tres capas. A veces se emplean claros filtros de luz. En el último caso, la tarea principal consiste en obtener la distinción máxima de colores de las rocas aunque sea un poco acusada, pero la misma durante el vuelo. Para las regiones boscosas o cubiertas de plantas herbáceas, donde las senas geobotánicas desempeñan un papel importante para el descifrado, se emplea la película espectrozonal, donde una de las capas es sensible a la zona infrarroja del espectro.

El coste del levantamiento aerofotógrafico sobre la película en colores y espectrozonal es los 10-20% nayor que sobre la película bicolor. Teniendo en cuenta el coste un poco más alto de los materiales fotográficos en colores, las positivas en colores se sacan de la película en colores alternativamente, una si y otra no. En calidad del par estereoscópico par el descifrado se emplean las positivas bicolores.

Todos los trabajos aerofotográficos se efectúan empleando aparatos especiales que aseguran la posición planimétrica de la fotografía y la altura precisa de vuelo del avión al sacar las fotografías (instalación hidroestabilizadora, estatoscopio y radioaltímetro).

El descifrado de las fotografías aereas se efectúa en conjunto con investigaciones terrestres y se verifica en tres etapas: antes de realizar los trabajos de campaña, durante éstos y al revisar difinitivamente los materiales. Además, la metodología aprobada en la URSS prevé la exploración terrestre de todo el territorio y no de las zonas claves separadas, como se practica a menudo en otros países. Esto asegura una valoración mucho más completa de la región desde el punto de vista de perspectivas para diferentes tipos de yacimientos.

Salvo las fotografías aéreas, al efectuar el descifrado geológico, se emplean esquemas y croquis fotográficos, dibujados en la escala del vuelo, y reproducciones de éstos disminuidas hasta la escala próxima a la escala de los trabajos que se realizan.

Los métodos de análisis de las fotografías aéreas se basan en el principio de efectuar el descifrado desde el punto de vista de paisaje, lo que es de importancia particular para la investigación de las regiones poco desnudas. Con esto se estudia y se analiza minuciosamente la relación de las formas del terreno y de la flora con el substrato geológico, se aprecia su significación geoindicativa para una región concreta, se revela la dependencia de las formas del terreno y de los movimientos neotectónicos. El descifrado complejo a base de paisaje permite dibujar los mapas geológicos de las regiones poco desnudas y de acceso difícil, con gastos mínimos para los trabajos de perforación y laboreo de minas.

Esto es de particular importancia para investigar las regiones de desarrollo de estructuras petrolíferas cerradas. Es sabido que unos 70% de los yacimientos petrolíferos mundia-

les están ligados don las estructuras enterradas de tipo plataforma, situadas en una profundidad considerable. En relación con esto se ha divulgado el método de identificación de las estructuras enterradas por indicios indirectos que se descifran en las fotografías aéreas: por formas del terreno, red fluvial, dibujo, grietas, tono de la imagen fotográfica, distribución de la flora, etc.

Este método se ha justificado por completo durante las investigaciones de las regiones boscosas y de bosques y estapas de la Ucrania y Bielorrusia, de las regiones semidesiertas de la Kazajia occidental y Tukrmenia, etc.

El descifrado visual (calitativo) de las fotografías aéreas, empleando el estereoscopio, es acompanado de mediciones instrumentales en éstas. El disenado y la fabricación de los instrumentos para estos fines prevé la posibilided de su empleo por geólogos que no tienen una preparación fotogramométrica especial, lo que permite emplearlos ampliamente durante los trabajos geológicos.

De los instrumentos más usuales es necesario fijarnos en los dos.

El instrumento fotogramométrico más sencillo es la paleta del geólogo descifrador (fig.1). Es de simple estructura, portátil y puede emplearse directamente en condiciones de campana.

La paleta permite medir por las fotografías aéreas, sin emplear el estereoscopio, el desnivel de un punto del terreno respecto a otro, con una precisión de 1/500 a 1/700 de la altura en la que se sacan fotografias, y determinar los elementos de disposición de las capas con una precisión que, por regla general, es un poco superior a la de la brújula de montana.

Para efectuar mediciones en condiciones de laboratorio se emplea estereómetro geológico (fig.2). Este instrumento sirve para resolver un conjunto de problemas: identifical los elementos de yacimiento de las rocas, determinar las pendientes del terreno, el espesor de las capas, los desniveles de un punto respecto a otro; trazar sobre la fotografía aérea las proyecciones de salida a la superficie de la capa horizontal o monoinclinada. El estereómetro geológico permite medir el grosor de las capas y los desniveles con una precisión de 1/800 a 1/1000 de la altura del levantimiento aerofotográfico. El error medio cuadrático, al medir los ángulos de caída, es igual a 1,2°, y la precisión en determinar el azimut de la extensión de las capas con los ángulos de caída superiores a 5°, es de 3 a 5°.

Los mapas geológicos confeccionados con el amplio empleo de los resultados del descifrado, son altamente precisos según el dibujado y la argumentación de los perfiles, mientras que los gastos de tiempo para su confección son 1,5 veces menores en comparación con el dibujado de los mapas por métodos terrestres ordinarios.

Las fotografías aéreas prestan mucha ayuda al efectuar los trabajos de prospección.

Uno de los objetivos es la prospección directa de yacimientos. En este caso los indicios directos de descifrado para la prospección son el cambio del tono o color en la fotografía aérea, así como las formas específicas del terreno. De este modo se puede contar con la revelación de algunos yacimientos tales comc hulla, mineral de hierro y manganeso, materiales de construcción. En algunos casos, especialmente al discifrar las fotografías aéreas en colores, pueder verelarse minerales de cobre, capas de hierro sobre los yacimientos de polimetales, zonas de desarrollo de la corteza de intemperismo en macizos de hiperbasitos, a los cuales suele acompanar la mineralización de niquel, etc.

Sin embargo, de más amplio empleo son los indicios de descifrado indirectos. Así, por las fotografías aéreas pueden identificarse zonas de desarrollo de los filones de roca eruptiva y rupturas en intrusiones, igual como otras partcularidades de estructura de los prutonos de granita que puedan ser zonas de concentración de yacimientos. Con igual nitidez se descifra a menudo en todos los pormenores las estructuras plegadas en formaciones sedimentarias, lo que es de primordial importancia para los geólogos petroleros. Al buscar los placeres minerales es posible, ya en el período del descifrado preliminar de laboratorio, basándose en el conocimiento del régimen hidrodinámico del río, determinar las zonas enriquecidas de minerales de la fracción pesada, calcular el espesor del aluvión guijarreno en cualquier parte del cauce o valle y proyectar con orientación los trabajos de prospección y exploración ulteriores. El empleo de los métodos geobotánicos permite servirse de la flora como de un indicador de tales o cuales elementos químicos que haya en la tierra.

El empleo de las fotografías aéreas durante los trabajos de investigación geológica hace correcciones esenciales en la metodología de su realización. En vez del curso ordinario de los trabajos: manifestación del mineral - yacimiento -campo del minera, el geólogo tiene la posibilidad de examinar en un plazo relativamente reducido los alrededores de la zona que se investiga, revelar si hay zonas adyacentes con estructuras próximas a la que se explora y, trazando una cantidad mínima de itinerarios, ya en el inicio de los trabajos tener una idea sobre la estructura del campo del mineral en total. El empleo de las fotografías aéreas permite sustituir los caros trabajos topográficos y geodésicos de confección de mapas de escala grande, de determinación de cotas de los horizontes de referencia, excavaciones, pozos de perforación puntos de observación geológicos y geofísicos, valiéndose de los procedimientos fotogramométricos más rápidos y baratos.

Se resuelven bastante simple y precisamente los problemas de identificación en el terreno de cualquer punto de la fotografía aérea.

Las fotografías aéreas ocupan un lugar particular al estudiar la estructura geológica del fondo del mar en las zonas de poca profundidad. Los trabajos efectuados en el mar Caspio han mostrado que valiénodose de las fotografías

aéreas es posible determinar la composición substancial de las rocas, condictiones de su yacimiento, formas y caracter de plegamientos y rupturas. La fotografía aérea del fondo marítimo se efectúa sobre la película ortocromática PP-1 ó PP-3 empleando los filtros de luz amarillos oscuros, con la altura del sol no inferior a 15-20° sobre el horizonte,y a medida de posibilidades, la bonanza y transparencia suficiente del agua.

b) Estudio del suelo

El desicifrado de las fotografías aereas, al confeccionar los mapas de suelo, guarda los procedimientos principales de los trabajos terrestres, pero el volúmen de los trabajos de compana se reduce considerablemente y la calidad de los mapas va mejorándose cada vez más. Las fotografías aéreas permiten analizar con mayor profundidad la relación mutua entre los componentes del paisaje, formas del terreno,flora, diferencias en el humedecimiento de diferentes zonas y muchos otros detalles importantes.

El descifrado comienza con destacar los contornos del suelo por diferencias tonales y cambio del dibujo de la imagen fotogáfica. La revelación del suelo en los límites del contorno se verifica estableciento las causas que acondicionan la diferencia de la imagen fotográfica. Estas causas se decubren por investigaciones terrestres durante el descifrado de campana de las fotografías aéreas.

Se ha establecido que el empleo de los materiales de la fotografía aérea es eficaz para cualquier paisaje, confeccionando los mapas de suelo tanto de escala grande como media. El mayor efecto se logra en las zonas de tundra, de estepas secas y desiertos. En estas regiones el rendimiento de trabajo de los operarios que levantan el terreno, aumenta 2 ó 3 veces. Sin embargo, en las regiones boscosas, basándose en el papel indicador de la flora, el discifrado del suelo puede efectuarse también con bastante eficacia. Unn ejemplo de esto pueden ser los trabajos realizados en los últimos anos en Bielorrusia y Ucrania.

En las regiones áridas, valiéndose de la flora como del indicador de grado y caracter de la salinidad del suelo, a base del descifrado se dibujan mapas del dinamismo de salinidad, lo que tiene una importancia indudable para la planificación de la puesta en cultivo de los territorios.

De acuerdo con los detalles del mapa de suelo, la escala de la fotografía aérea varía de 1:50000 a 1:25000. Es útili combinar el levantamiento fotográfico de escala pequena con el de gran escala, efectuándolos por itinerarios en cruz de la extensión de formas del terreno principales, así como en las zonas más complicadas o de interés particular. El pariodo más favorable para efectuar el levantamiento fotográfico suele sar primavara y otono, y para les regiones puestas en cultivo agrícola, el período entre la labranza y el crecimiento párido de cereales. Las mejores cualidades poseen las positivas en colores sacadas de la película espectrozonal, porque éstas permiten con mayor seguridad y pormenores efectuar el descif-

rado de los suelos.

c) Estudio de la flora

Las fotografías aéreas dan un rico material tanto para estudiar la flora, como para las investigaciones geobotánicas indicativas. En el último caso el descifrado geobotánico se efectúa como un medio auxiliar obligatorio al realizar las investigaciones geológicas, de suelos, hidrológicas y otras de los recursos naturales.

Las fotografías aéreas se emplean más ampliamente para estudiar bosques.

Al efectuar el cálculo aéreo de los recursos forestales, en calidad de materiales de partida para el descifrado topográfico de contornos, se emplean fotografías aéreas de la escala 1:25000, y más raramente de la escala 1:15000 - 1:10000. Se cambia correspondientemente la escala de trazar las zonas. Más a menudo se emplean fotografáas espectrozonales aéreas sacadas en verano.

El cálculo de los recursos forestales durante la organización forestal se efectúa por fotografías aéreas en las que están trazadas de antemano las zonas y descifrada la base topografica.

Para la organización forestal de I- II categoría la escala aprobada de fotografías aéreas es 1:10000 - 1:15000; de III - IV categaría, 1:20000 - 1:30000. Las mediciones estereofotogramonétricas permiten determinar la altura de los árboles y la anchura de las copas con un error cuadrático medio de unos 10-13%.

Las fotografías aéreas dan la posibilidad de reducir el volumen de los trabajos terrestres, trazar más precisamente los márgenes de los tipos diferentes del bosque, acelerar la confección de los mapas. Las fotografías aéreas abren unas amplias perspectivas para el estudio del estado de los bosques en diferentes estaciones.

Al estudiar la flora de las regiones de estepa, semidesiertas y desiertas se emplea el metodo de paisaje del descifrado que se base en la distinción consecutiva de las unidades territoriales cada vez menores.

Este metodo permite trazar, en margenes de una región limitada, bastante razonable, precisa y detallademente, los límites entre las zonas destacadas, dividiendo los groupos de flora hasta formaciones o conjuntos de asociaciones, distinguir los tipos de postos y campos agrícolas. Una lista de indicios para el descifrado de los paisajes analógicos permite emplear los materiales, obtenidos para unas regiones, en el estudio de otros territorios de paisaje parecido. De este modo pueden investigarse pastos, campos de heno, etc.

Al estudiar y valorar los recursos de flora de los mares, de hecho sólo el levantamiento aéreo es el que puede proporcional los contornos vardaderos de las lugares de crecimento de algas en la zona de poca profundidad y de las

areas de difusión del fitobentosis. El descifrado en esto caso se efectúa valiéndose de llaves de analogía teniendo en cuenta el caracter del fondo marítimo y del medio acuoso. De acuerdo con las condiciones de la naturaleza, el levantamiento aerofotográfico se efectúa sobre la película ortocromática, pancromática o espectrozonal.

e) Estudio de los recursos acuáticos

Efectuando las investigaciones hidrogeológicas o hidrológicas, el análisis de las fotografías aéreas otorga tales resultados los que no puede proporcionar ningún otro procedimiento.

Al resolver los problemas de abastecimiento de agua de las regiones áridas donde los pozos se alimentan de aguas dulces o poco salobres, en lo principal, a costa de aguas someras, las fotográfías aereas prestan un servicio inapreciable. El descubrimiento de los lentes de aguas someras se verifica estableciendo la relación de los últimos con las formas del terreno y la litología de las rocas y el reflejo de esta relación en la flora. El descifrado ulterior de los lentes de aguas dulces se efectúa valiéndose del metodo de llaves de analogía.

El levantamiento aéreo para los fines hidrológicos en las regiones áridas se realiza sobre la película espectrozonal en el parfodo de mayor distinción de las asociaciones de freatofitos. Teniendo en cuenta que las dimensiones de los lentes de aguas someras son a menudo reducidas, la escala óptima para fas fotografías aéreas es 1:10000 - 1:15000.

Al estudiar las aguas superficiales se ha quedado establecido ya hace mucho que ningun levantamiento terrestre está en condiciones de reflejar todos los serpenteos caprichosos de las corrientes de agua. El levantamiento aerofotográfico ha solucionado fácil y eficazmente este problema dando la posibilidad de no sólo trazar con la más alta precisión los contrnos de la superficie acuosa, sino también restituir estos contornos para diversos épocas y pronosticar los cambios ulteriores de las litorales. Empleando el método fotométrico es posible determinar con bastante precisión la profundidad de los depósitos de agua por el tono de la imagen del fondo si la profundidad del depósito de agua es de 3 a 5 metros. Las formulas obtenidas para tomar en cuenta las tergiversaciones de imágenes de las formas del fondo han dado la posibilidad de determinar la profundidad de los depósitos de agua empleando los procedimientos estereofotogramométricos.

Las nuevas posibilidades de obtener las características de los depósitos de agua se emplean en conjunto con los procedimientos ordinarios. De una parte, éstas sirven para un control objetivo, de otra, permiten efectuar toda clase de interpolación y extrapolición, con la cual los trabajos de levantamiento terrestre, reducidos hasta el mínimo, pueden emplearse en calidad de referencias

Los problemas arriba mencionados no abarcan, sin duda, todas las ramas de empleo del levantamiento aerofotográfico para estudiar y explotar los recursos naturales. Un gran servicio hase éste para el estudio del régimen de hielos, para proyectar ferrocarriles y carreteras, conductos, líneas de transmisión eléctrica, etc. Los métodos de ejecución del levantamiento aerofotográfico para diferentes fines económicos y el empleo de las fotografías aéreas para resolver los problemas concretas están elaboradas en la URSS bastente y siguen perfeccionándose cada ano más. El tradajo principal está encaminado para perfeccionar aún más estos métodos en el estudio de las regiones menos investigadas y de acceso difícil.

## COMPENDIO BIGLIOGRAFICO RECOMENDABLE


Levantamiento aerogeológico de las zonas de baja profundidad del mar Caspio.

Colección de artículos. Redactado por V.V.Sharkov.L.,1958

Métodos aéreos de estudio de los recursos naturales.

Redactado por D.M. Kudritzkiy y G.G.Samoilavitch, M.1962.

V.M. Bariguin y otros. Empleo de los métodos aéreos para la prospección de los yacimientos nativos de diamantes. Editado por la Academia de Ciencias de la URSS, 1960.

S.V. Belov. Levantamiento aerofotográfico de bosques. Editado por la Academia de Ciencias de la URSS,1959.

V.N.Brujanov. Vías de empleo de los materiales fotográficos aéreos en colores con fines geológicos. "Razvedka y ojrana nedr", No.2, 1962.

S.V. Victorov, E.A. Vostokova, D.D. Vishivkin. Breve guía para el levantamiento geobotánico. M.1959.

B.V. Vinogradov. Método aéreo para la confección de mapas le los pastos. "Vestnik selscojozaistvennoy nauky", No. 11, 1958.

E.A. Galkina, S.S. Guileev, K.E. Ivanov, E.A. Romanova. Empleo de los materiales de levantamiento aerofotográfico para el estudio hidrográfico de pantanos. "Trudy Gosudarstvennogo guidrologuichescogo instituta", ed.13,L., 1949.

L.M. Goldman. Empleo del levantamiento aerofotográfico sobre la película en colores para el estudio del terreno. Trudy ZNIIGAyK, ed.37, 1960.

Empleo de los métodos aéreos para la investigación de los recursos naturales. Colección de artículos. L., 1961.

D.M. Kudritzky, I.V. Popov, E.A. Romanova. Principios del descifrado hidrografico de las fotografías aéreas.L.,1956.

J.A. Liverovskiy. Empleo de los métodos aereos para el estudio del suelo "Pochvoyedenie" No.6. 1957.

M.N. Petrusavitch. Métodos aéreos para las investigaciones geológicas. M., 1962.

Empleo de los métodos aéreos para las investigaciones geológicas del fondo marítimo. Breve guía metodológica redactada por V.V.Sharkov y D.M. Kudritzky, L. 1956.

Guía para la ejecución de vuelos y observaciones en la exploración aérea de hielos. L-M, 1953.

B.S. Rusanov. Métodos aereos de confección de mapas geomorfológicas para la prospección de placeres, M. 1951.

G.G. Samoilovitch. Empleo de aviación y levantamiento aerofotográfico en la economía forestal, M-L, 1953.

Trudy Vsesoyuznogo aerogeologicheskogo tresta No. No. 1-8, 1955- 62.

Trudy Laboratory aerometodov t.t. I-X, 1949-61.

J.M. Trunin. Nuevos instrumentos fotogramométricos para los fines geológicos. "Razvedka y ojrana nedr", No. 4, 1962.



544 S - Nov.1962 - 600

E/CONF.39/A/174/Corr.1
10 Jan.1963
ENGLISH
ORIGINAL : RUSSIAN

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

# C O R R I G E N D U M

Agenda Item A.1.1 should read : A.

544 E - Jan.1963 - 1,600

E/CONF.39/A/174/Add.1
7 Jan.1963
ESPAÑOL
ORIGINAL : RUSO

CONFERENCIA DE LAS NACIONES UNIDAS
SOBRE LA APLICACION DE LA CIENCIA Y LA TECNOLOGIA
EN BENEFICIO DE LAS REGIONES MENOS DESARROLLADAS

---

# A D D E N D U M

Le ruego que añada las dos figuras adjuntas.

544 S - Jan.1963 - 600

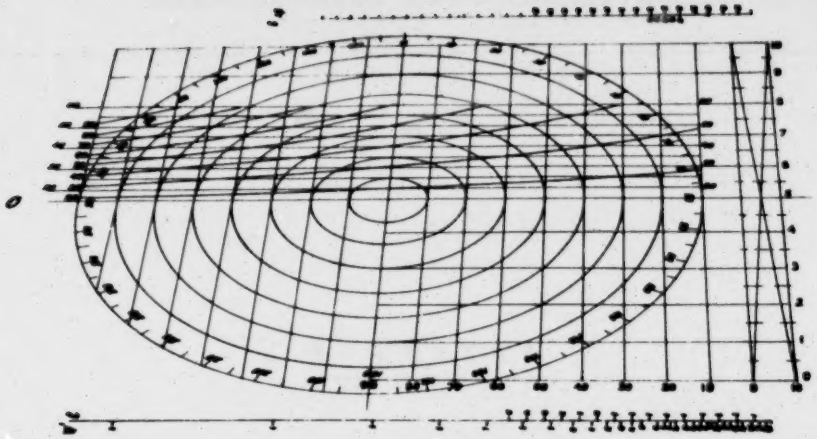


Fig. 1

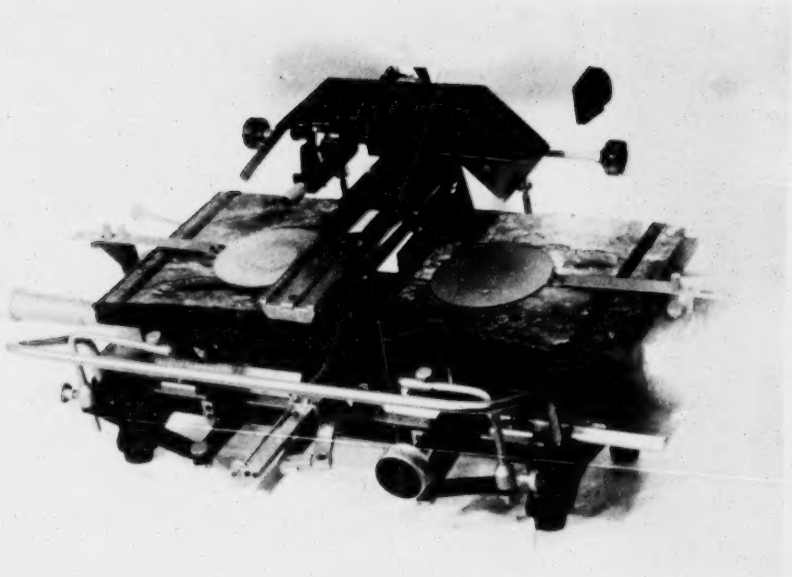


Fig. 2

E/CONF.39/A/174/Rev.1*
19 Dec.1962
ENGLISH
ORIGINAL : RUSSIAN

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.1.1

Byelorussian SSR

# THE UTILIZATION OF AEROPHOTOGRAPHY FOR REVEALING AND ESTIMATING NATURAL RESOURCES

By V.N. BRUKHANOV,
Geological Engineer

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

* This document supersedes the previous edition published under document symbol E/CONF.39/A/174 of 20 November 1962

E/CONF.39/A/175

## NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

# THE UTILIZATION OF AEROPHOTOGRAPHY FOR REVEALING AND ESTIMATING NATURAL RESOURCES

by

V.N. Brukhanov, Geological engineer

Aerophotography in the USSR is used for the exploration of the natural resources especially in the areas which were hitherto poorly investigated;,this method increases the efficiency of the work, reduces the interval and the expenses involved with the performance of the examinations. The materials produced by aerophotography are of especial significance in the course of studying the remote and poorly accessible areas similar to the vast desert planes, mountain ranges, massives of tropical and subtropical woods etc.

a/ Geological works

Aerophotography is of great value for the performance of geological works.

Special rational parameters are developed for aerophotography when the latter technique is used for geological mapping. It enables to produce aerophotopictures which reveal a high standard of deciphering properties. For the estimation of the parameters required for aerophotography one ought to take into consideration the landscape peculiarities of the area and also the scale and the task purpose of the geological works. The scale of the aerophotography is chosen with a due account of the scale of the geological investigations and the complexity of the geological structure in the examined area. When the geological mapping is to be carried out at a scale of 1:200 000 the scale of the airplane pictures ranges from 1:25 000 to 1:50 000; when the mapping is performed at the scale of 1:50 000 it varies within the limits of 1:10000 up to 1:25 000.

The time of the year for aerophotography is selected in accordance with the specific features of the landscope (the presence of utmost contrasts in the moistening properties of rocks, the vegetation, the number of clear days with good visibility, the state of the atmosphere etc.).

The daylight hours and the selection of the focal length for the aerophotographic works are determined by the relief of the area. In the plain areas aerephotography is carried out during the early morning or the early evening hours with the use of short focal aerophotodevices (f 100) which permits to stress the forms of the relief. In the mountain areas it is better to perform work during the hours which are close to noon and the focal length should be 200 or more.

For the purpose of revealing areas with multicoloured rocks it is advisable to use a three layer coloured aerophotofilm which sometimes should require filters. In the latter case the basic object of the exploration is to produce a maximum colour division of the rocks. This picture may be somewhat distorted but should be of a uniform character within the limits of a single flight. A spectrozonal film is used in the populated areas or in those which are covered with grass vegitation and where the geobotanical characters play an important role in the course of the diciphering

works. One of the layers of this film is sensibilized to the infrared zone of the spectrum.

The expenses involved with the aerophotographic works when the coloured and the spectrozonal films are required are about 10-20% higher than those done with the white-black films. And, hence, bearing in mind the somewhat higher cost of the coloured aerophotomaterials the coloured aeroplane pictures are frequently prepared from the aerophotofilms in a skipping manner (every other one) and for deciphering one uses the black-white picture as a stereo-pair.

All the aerophotographic works are performed with the aid of special devices which provide the carefully envisaged position of the aerophotopicture and an accurate altitude 'attachment' of the plane during the photographic operation (gyrostabilizing device, statoscope and radioaltitude meter).

The deciphering of the aerophotopictures is carried out in close contact with the land investigations and is performed in three stages: prior to the field studies, during the field works and during the final treatment of the geological materials. The technique adopted in the USSR provides for the land research of the entire territory and is not restricted to the study of single key areas as it is frequently practised in other countries. This approach enables to obtain a more complete evaluation of the area from the viewpoint of the prospects for the development of the mineral resources.

Apart from aerophotopictures the geological deciphering requires the use of photoschemes and photoplans compiled at the scale of the flight and reproductions taken from them; the latter are reduced to a scale close to the scale of the executed exploratory works.

The methods for the analysis of the airplane pictures are based on a landscape approach to the deciphering operations which is a matter of great importance for the study of the poorly exposed areas. These analitical works provide for the study and careful examination of the connections between the relief and the geological substrate. The geoindicative significance of these relationships for the study of a concrete area is emphasized and the dependence of the relief forms upon the neotectonic movements is established in the coursea of investigations. The comples landscape deciphering permits to carry out geological mapping in the scarcely exposed and poorly accessible areas with a minimum of financial support usually required for the development of the drilling and the mining works.

This is of great importance for the study of areas with a developed system of enclosed oil fields. It is known that about 70% of the world's oil deposits is closely connected with the buried structures of the platform types bedded at considerable depths. Owing to this there has been elaborated a method for the exposure of the buried structures which is based on indirect characters which are deciphered on the aerophotopictures and has won wide acknowledgement. These characters are: the relief, the hydronetwork system, the general layout, the jointing, the tone of the photoreproduction, the distribution of vegetation etc.

This method has fully justified itself in the course of investigating the forest and the forest-steppe areas of the Ukraine and the Belorussia, the semidesert areas of the Western Kazakhstan and Turmenia etc.

The visual (qualitative) deciphering of the aerophotopictures under the stereoscope is accompanied by exact instrumental measurements. The designing, construction and the production of devices for these works is developed along the lines of their implementation by the geologists and, hence, enables to introduce these new techniques into the practice of routine field work.

Two of the more widely known and used devices deserve mentioning.

The most simple photogrammetric device is a 'paletka' (transparent sheet divided into squres) used by the geologist engaged in deciphering work (refer to fig.I). This device is portable and can be used in field work. It permits to measure the relative overlaps in locality sites making the best use of the aerophotopictures without using the stereoscope. These measurements are done with an accuracy of 1/500-1/700 of the altitude from which the picture was taken and permit to estimate the bedding elements (the strate) with an exactness which, as a rule, exceeds the accuracy of a mountain compass.

Measurements under laboratory conditions are carried out with the aid of a geological stereometer (fig.II). This device is intended for the solution of several problems: for the determination of elements of the rock bedding; the determination of the inclination angle of the slopes in the area; the estimation of the seam's thickness; the determination of the relative excess; the plotting of the exit projection onto the daylinght surface of the horizontal or the monocline dropping seam of the aeroplane picture. The accuracy in the determination of thickness and excessive characteristics noted in the geological stereometer amounts to 1/800-1/1000 of the altitude from which the photograph has been taken. The average quadratic arror in the course of measuring the angle of dip amount to ± 1.2° and the accuracy for the determination of the azimuth trend of seams with angles of dip exceeding 5° lies withnin the range of 3-50.

The geological charts compiled with a wide utilization of the results obtained from the deciphering operations are most exact in regard to the drawing and the substantiation of the contours and the expenditure of time required for this operation which is 1.5 times less than the time necessary for compling charts by using routine technique adopted for land mapping.

Aerophotography is most helpful for prospecting works.

The direct method for the exploration of deposits of commercial minerals incorporates the utilization of deciphering criteria involved with the variations of tone or colour in the aerial pictures; due account is also given to the specific forms of the relief. Thus, it is possible to reveal some minerals of commercial significance such as coal, iron and manganese ores and materials for construction works. In some cases, usually when deciphering coloured aerophotographic pictures, one can observe copper mineralization, iron hats covering the polymetal deposits, sites of developed weathered crust in the ultrabasite massives to which at times the nickel mineralization is attached and etc.

However, the indirect criteria for prospecting deciphering enjoy a much wider application. For example, with the aid of aerophotographic pictures one can trace the sites of

development of dikes and the fractures in the intrusions and other specific features noted in the structure of the granite plutons which may serve as key centres for the concentration of mineral wealth. Nonless frequently it is possible to decipher in detail the folded structures in the sedimentary formations. This fact is of great importance for the specialists working in the field of petroleum geology. When engaged in prospecting placer accumulations, during the period of preliminary laboratory deciphering there is a possibility, on the basis of the knowledge of the hydro-dynamic regime of the river, to single out the sites enriched with the minerals of the heavy fraction, to calculate the thickness of the pebble alluvium at a random area of the river-bed or flood plain and to carry out an expedient projection required for the further exploration and prospection. The application of the geobotanical methods to utilize vegetation as an indicator for chemical elements hidden beneath the soil-ground cover.

The use of the aerophotopictures for works dealing with geological prospecting introduces substantial corrections into the methods of these operations. Instead of applying the commonly used procedure i.e. ore manifestation--deposit area-ore field, the geologist has a possibility to review the vicinity of the investigated area during a comparatively short period of time and to trace whether there are in the adjacent sites areas which are structurally adherent to the one under examination; and having carried out a minimum number of routes acquire from the very beginning a uniform idea on the structure of the ore field as a whole. The application of the aerophotopicture technique permits to substitude the expensive and costly topographic and geolesic works devoted to the mapping of large-scale charts, which are based on the allocation of single marking horizons, mining exploration, drilling wells, points for geological and geophysical observations and to introduce cheaper and more efficient photogrammetric methods.

The tasks involved with the plotting of any fixed point traced on the aerial picture can be solved quite easily and with great precision.

Aerophotogra  plays an exceptionally great role for studying the geological structure of the shallow water area of the sea bottom. The works in the area of the Caspian Sea that the aerophotographic pictures frequently permit to establish the substance content of rocks, to estimate the substance content of rocks, to estimate the conditions of their bedding, the form and the character of the foldings and and the fracture disorders. The aerophotographic pictures of the sea bottom is performed with the aid of orthochromatic aerophotographic films RF-I or RF-3 and with the use of dark-yellow filters when the position of the sun in regard to the horizon is not less than 15-20°. The aerial photographic survey should be performed preferebly under conditions of an entirely calm sea when the water transparancy is sufficiently high.

b) Soil research

In the course of soil mapping the deciphering of aerophotographic pictures maintains the basic technique adopted

for land works, but the scope of field work is considerably reduced, whereas the quality of the charts progressively improves. The aerophotographic pictures permit to accomplish a most complete analysis of the landscape components and their interrelations with the relief, vegetation, the difference of the moisture content in separate sites and numerous other details.

The deciphering begins with the singling out of soil contours according to tone differences and the change of the picture of photoreproduction. The determination of soils within the contour range is carried out during the establishment of causes responsible for the difference of photographic images. These causes are being revealed by means of land investigations along with the field deciphering of the aerophotographic pictures.

It has been established that the utilization of materials produced by the aerophotographic technique may be effectively applied to any types of landscapes both for compiling largescale and average-scale soil maps. The most efficient result is attained in the tundra, the dry steppe and desert zones. In the mentioned areas the labour efforts on behalf of the survey personnel and the efficiency of their work increases by 2-3 times. However, in the reforestated areas, as it is clear on the basis of revealing the indicative role of vegetation, the deciphering of soils and grounds can be accomplished most successfully. Similar works have been carried recently in the Belorussia and in the Ukraine.

Having used the vegetation as an indicator of the rate and character of soil and ground salinization in the arid areas there have been developed maps of salinization dynamics on the basis of decipher-ing technique. This work is of undoubtable significance for the development of the planning system in regard to the needs of farming in the newly cultivated areas.

The scaling of the aerophotographic survey works depends strongly upon the detailed mapping of the soil charts and ranges from 1:5000 to 1:25 000. The combination of the small-scaled surveys with the large-scaled-technique carried out along separate routes transversely to the run of the basic relief elements and also at the most complex areas or sites which are of some particular interest is viewed as a most useful method. The spring and autumn are regarded as the most favourable seasons for aerophotographic survey works and for agricultural areas it is best to carry out airplane photography during the period between ploughing and the rapid development of the herbs' sprouts. The coloured prints produced from the spectrozonal aerophotographic film reveals the highest efficiency for they permit to carry out soil deciphering more reliably and in greater detail.

c) Vegetation research

Aerophotographic pictures are most helpful for the study of the vegetation wealth and produce ample material for indicative geobotanical investigations. In the latter case geobotanical deciphering is being carried out as an obligatory auxilliary procedure in the course of geological, soil, hydrogeological and other types of exploring natural resources.

Aerophotographic technique is most widely applied for the study of the forest resources.

The initial materials for aerotaxation in cases of contourtopographic deciphering are the aerophotographic pictures with a scaling of 1:25 000 and more rarely of 1:15 000 - 1:10 000. The divisibility for the singled out areas changes respectively. The spectrozonal aerophotographic pictures produced during the summer months are used most frequently.

The forest taxation in the course of forest management is based upon the pictures into which the boundaries of the taxative areas are introduced afore and the topographic base is deciphered. For the purpose of forest management according to the Ist and 2nd categories it was found advisable to adopt the following scaling for aerophotographic pictures 1:10 000- 1:15 000 and the 3rd and 4th category requires 1:20 000 - 1:30 000. The stereophotogrammometric measurements permit to determine the height of the trees and the width of the tree top with an average quadratic error of 10-13%.

The availability of aerial pictures enables to reduce the scope of the land work and most accurately map the boundaries of different types of woods and to hasten the production of maps. Aerophotographic technique opens wide possibilities for the study of the state of forests throughout various seasons.

The landscape method of deciphering based on a sequential singling out of progressively smaller territorial units is applied for the study of vegetation in the steppe, semi-desert and desert areas. This method permits, within the limits of a restricted area, to obtain an adequately substantiated boundary line between the distinguished areas, to dismember the vegetation groups to the formations or group accociations, to reveal the types of pasture grounds and the farming lands. The prearranged method for deciphering landscape-analogues permit to use the materials produced for certain areas for the study of other territories which reveal similar landscape features. Thus, it is possible to explore pasture grounds, haymaking areas etc.

Aerophotographic technique proves to be the sole method for the investigation and the estimation of vegetation resources hidden in seas for only this method is liable to produce the true contours for tracing the growth areas of algae in the shallow water zones and the areal distribution of the phytobenthos. In this case the deciphering is accomplished by the method of key-analogues with a due account of the specific features of the sea bottom and the water environment. Aerophotographic surveys are carried out in relation to natural conditions and may be done on orthochromatic, panchromatic or spectrozonal films.

d) The study of water resources

In the course of hydrogeological and hydrological investigations the analysis of the aerophotographic pictures frequently produces such results which cannot be attained by any other techniques.

The solution of problems involved with water supply in the arid areas where the water wells are fed with fresh and slightly salted waters is accomplished basically at the cost of leakage water and the assistance of aerial photography in this case is hard to overestimate. The technique for revealing leakage water lenses is implemented on the basis of establishing relations between the latter and the shape of the landscape (relief) and the rock lithology and the reflection of this connection in the vegetation cover. The subsequent deciphering of the freshwater lenses is carried out by applying the method of key-analogues.

Aerophotographic surveys for hydrogeological purposes in the arid areas is carried out during the period of utmost differences noted in the phreatophyte communities in regard to the spectrozonal film. Having taken into consideration the size of the leak-age water lenses, which is frequently insignificant, the optimum scale of aerophotographic pictures is 1:10 000-1:15 000.

The study of surface waters showed long ago that no kind of land survey examinations is able to cover all the intricate twists of the water flows. Aerophotographic survey technique has solved this problem in a very easy and simple way and has provided man with maximum knowledge concerning the distinct traits of the water surface and has also permitted to reconstruct its contours throughout different epochs and to forecast the further changes of the coastline. Having applied the photometric method up to the depth of 5 m. one may estimate the depth of the basin with adequate accoracy according to the image tone of the bottom. The production of formulas for the careful consideration of the distortions which may have appeared in the representation of the submarine relief has enabled to estimate the depth of the basin and this has been accomplished by means of the stereophotogrammometric technique.

The new possibilities for obtaining the basis characteristics of the aquatic objectives are combined with the routine methods. On one hand, they appear as objective control tests and, on the other hand, they permit to carry out various sorts of interpolations and extrapolations when the land observations are next to minimum and can be used as reference guides.

x x

x

The numerated problems doubtlessly cover all the possible aspects for the application of aerial photography for the purpose of studying and exploiting the natural resources. This method is very handy for the study of the ice regime, for the projection of railroads and highways, pipe lines, lines for the transmission of electric energy etc. The methods for conducting aerophotographci surveys for various economic purposes and the utilization of this method for the solution of concrete problems has been develpped at a high rate in the USSR and is progressively advancing in the course of each following year. The main tendency lies in the further improvement and perfection of this technique which will enable it to explore the less known and remote areas.

Brief list of references


Aerological survey of shallow water zones in the Caspian Sea. Collection of papers. Edited by V.V.Sharkov.Leningrad,1958.

Aeromethods for the study of natural resources. Edited by D.M.Kudrizky and G.G. Samoilovich, Moscow,1962.

V.M.Barygin and others. The application of aerial methods for the exploration of key deposits of diamonds. USSR Academy of Sciences Publishers, 1960.

S.V. Belov. Aerophotographic surveys of forest. USSR Academy of Sciences Publishers,1959.

V.N.Brukhanov. The ways of using coloured materials obtained from aerial photography for geological purposes. Prospecting and preservation of mineral resources' No.2,1962.

S.V.Viktovor, E.A. Vostokova, D.D. Vyshivkin. Brief guide for geobotanical surveys. Moscow,1959.

B.N.Vinogradov. The aerial method for pasturage mapping, Herald of Agricultural Science' No.II, 1958.

E.A. Galkin, S.S.Gileiv, K.E. Ivanov, E.A. Romasheva. The application of aerial survey materials for the hydrographic studies of swamps. 'Thudy of the State Hydrological Institute, Issue 13, Leningrad,1949.

L.M. Goldman. The application of colored aerophotographic survey for areal studies. Trady of the Central State Research Institute of Aerial Photography and Cartography.Issue 37, 1960.

The use of aerial methods for the investigation of natural resources. Collection of papers, Leningrad,1961.

D.M. Kudrizky, I.V. Popov, E.A. Romanova, The basis of hydrographic deciphering of aerophotographic pictures, Leningrad,1956.

Y.A. Leverovsky, The use of aerial methods for soil science. 'Soil Science', No 6, 1957.

M.N. Petrusevich. The use of aerial methods for geological research. Moscow,1962.

The application of aerial methods for the geological research of the sea bottom. A brief methodical guide edited by V.V.Sharkov and D.M. Kudrizky, Leningrad,1956.

A guide for flight operations and observation work for aerial ice field reconnaissance. Leningrad-Moscow,1953.

B.S.Rusanov. Aerial methods for geomorphological mapping in the course of placer explorations, Moscow,1951.

G.G. Samoilovich. The use of aviation and aerial photography for forest research, Moscow-Leningrad,1953.

The Trudy of the All-Union Aerogeological Trust No.1-8, 1955-1962.

The Trudy of the laboratory of Aerial methods. Vols.,1-X, 1(49-1961).

Y.M. Trunin. New photogrammetric instruments for geological purposes, 'Prospecting and presearvation of the mineral wealth', No. 4, 1962.

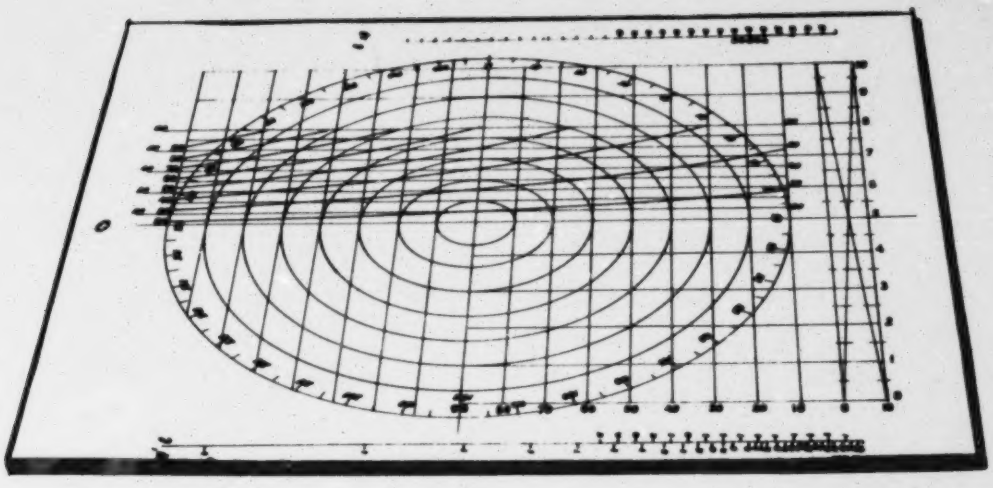


Fig. 1

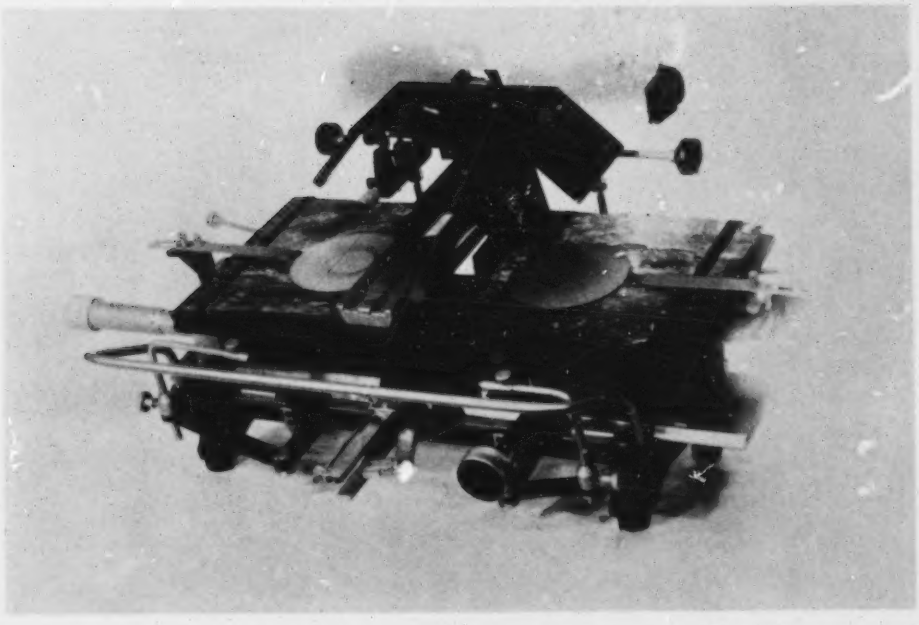


Fig. 2

544 E - Nov. 1962 - 1,600

E/CONF.39/A/175
26 Oct.1962
ORIGINAL : ESPAÑOL

CONFERENCIA DE LAS NACIONES UNIDAS
SOBRE LA APLICACION DE LA CIENCIA Y LA TECNOLOGIA
EN BENEFICIO DE LAS REGIONES MENOS DESARROLLADAS

Punto del programa : A.3.3

España

# INVESTIGACION DE AGUAS SUBTERRANEAS EN PAISES SEMI-ARIDOS

Por Enrique DUPUY DE LOME SANCHEZ,
Ingeniero de Minas,
Vocal del Instituto Geológico
y Minero de España,
Director de la Compañía de Investigación
y Explotaciones Petroliferas, S.A.

Las monografías presentadas en la Conferencia de las Naciones Unidas sobre la Aplicación de la Ciencia y la Tecnología en Beneficio de las Regiones Menos Desarrolladas constituyen documentos de trabajo de dicha Conferencia. Se publican tal como han sido presentadadas por los colaboradores y los puntos de vista expresados en ellas corresponden a los colaboradores. (Veánse notas al dorso.)

## NOTAS

1. Las monografías seleccionadas para las Sesiones Generales serán distribuidas en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

2. Las monografías seleccionadas para las Sesiones Especiales serán distribuidas en la Conferencia únicamente en uno de los idiomas oficiales antes indicados.

3. Los resúmenes de las monografías presentadas por los colaboradores serán distribuidos en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

4. No se procederá a la distribución general de las monografías y resúmenes con antelación a la Conferencia. Unicamente serán publicadas en cantidades limitadas con antelación a la Conferencia para uso exclusivo de las delegaciones de los gobiernos participantes y de otros participantes autorizados. La publicación con posterioridad a la Conferencia y la distribución general de las actas y debates de la Conferencia seguirán las prácticas de las Naciones Unidas establecidds por ia Junta de Publicaciones de las Naciones Unidas.

# Investigación de aguas subterráneas

## en países semi-áridos

Enrique Dupuy de Lôme Sánchez

(Ingeniero de Minas, Vocal del Instituto Geológico y Minero de España,
Director de la Compañía de Investigación y Explotaciones Petrolíferas,S.A.)

## 1) Aplicación de la geología a la investigación de aguas subterráneas

Escribimos estas notas recogiendo en ellas la experiencia que personalmente hemos obtenido, durante cerca de 15 años dedicados a la investigación de aguas subterráneas en el Sur y Sureste de España, regiones que bien pueden calificarse como semi-áridas.

Durante este tiempo nos hemos visto obligados a ensayar diferentes sistemas de investigación, guiados para ello principalmente por los resultados que de cada uno íbamos obteniendo.

Desgraciadamente, el escaso espacio de que en esta ocasión podemos disponer nos impide exponer, siquiera sea de forma esquemática, el proceso que las investigaciones de agua subterránea han seguido en nuestro país, hasta llegar a la situación, realmente satisfactoria, en que actualmente se encuentra.

Es indudable que en estas regiones semi-áridas, el agua, para riegos y para abastecimiento de poblaciones, adquiere un valor muy elevado, que justifica plenamente la inversión de sumas considerables, tanto en los trabajos de captación de aguas superficiales, como en las investigaciones y labores de alumbramiento de aguas subterráneas.

Pues bien, la aplicación sistemática de las investigaciones geológicas al estudio de los problemas de alumbramiento de aguas subterráneas, nos ha convencido de que, con el empleo sucesivo de los más adecuados métodos de prospección, que expondremos seguidamente, pueden llegar a alumbrarse caudales muy grandes, cuyos caudales en los casos más desfavorables no suelen llegar más que hasta el 40 % o 50 % de la capacidad teórica de producción de cada cuenca hidráulica subterránea, pero que en casos favorables, y así lo hemos experimentado nosotros, pueden alcanzar incluso hasta el 90 % de la capacidad teórica de aquellas.

En general, el empleo de los diferentes métodos de prospección geofísica, como auxiliares de los estudios geológicos en las investigaciones de aguas subterráneas es aconsejable, y en muchos casos realmente insustituíble.

Ello no obstante, no puede ni debe descartarse nunca el empleo de la geología como base científica esencial en toda campaña de investigación de aguas subterráneas. En muchos casos, incluso, basta con los estudios geológicos como único método de investigación para conseguir localizar labores de alumbramiento con las que se extraiga prácticamente la total capacidad de producción de una cuenca.

Hasta tal punto es esto cierto, que en realidad puede afir-

marse hoy día que una campaña geológica bien orientada debe proporcionar resultados positivos en la investigación de aguas subterráneas en más del 75 % de los casos, y que, por el contrario, los resultados positivos obtenidos en labores de captación que no vayan precedidas y hayan sido localizadas mediante estudios geológicos serios deben atribuírse, más que a otra cosa, a un venturoso azar.

2) Método y fases sucesivas de investigación

No es posible establecer un método general de investigación hidrogeológica que sea aplicable a todas las regiones, ya que en muchos casos el desarrollo de los trabajos depende de la urgencia y naturaleza del problema, de las características climáticas y geológicas de la región, y de los datos y elementos cartográficos, hidrogeológicos, etc., de que se pueda disponer en el momento de la iniciación del estudio.

En líneas generales, sin embargo vamos a exponer cuál es, a nuestro juicio, el orden y naturaleza de los estudios que es aconsejable efectuar en una campaña de investigación de aguas subterráneas.

a) Estudio geográfico general

Deben estudiarse las características geográficas de la región, y especialmente su orografía, climatología, régimen de lluvias, nieblas, nevadas, etc.

Es necesario asímismo estudiar las características físicas de las formaciones que afloran en la región estudiada, especialmente desde el punto de vista de su porosidad, permeabilidad y consiguiente capacidad de infiltración del agua de lluvia. La determinación de las constantes de evaporación, infiltración y escorrentía son datos fundamentales en toda investigación hidrogeológica.

Finalmente, y atendiendo a las posibilidades de utilización de agua para riegos, deben considerarse las características edafológicas y agrícolas de la región, pues ellas impondrán el límite económico en cuanto a la extracción de agua.

b) Estudio geológico

Habrá de comprender:

$b_1$) Estudio estratigráfico de la región (preferible de escala de denominador no mayor de 1/50.000), incluyendo mapa estratigráfico, mapa litológico, representación cartográfica de las permeabilidades y capacidad de infiltración de las diferentes formaciones. Estudios de sedimentología, tendiendo especialmente a la determinación de las variaciones laterales de facies que puedan influir sobre la permeabilidad de las formaciones.

$b_2$) Estudio fotogeológico de la región, que ayudará a la confección de los mapas antes citados.

$b_3$) Trabajos paleontológicos y micropaleontológicos en apoyo de las observaciones estratigráficas.

$b_4$) Estudio tectónico. Habrá a su vez de comprender:

$b_{4-1}$) Determinación de los accidentes y elementos tectónicos locales y regionales que puedan influir en la disposición de los niveles acuíferos.

$b_{4-2}$) Estudio de las fallas y roturas que influyan, de forma positiva o negativa, en el régimen de circulación de aguas subterráneas.

$b_{4-3}$) Investigación de los fenómenos de diapirismo y halocinesis, tanto desde el punto de vista de la circulación de aguas subterráneas, como por su influencia en la salinidad de las mismas.

$b_{4-4}$) Determinación de las unidades estructurales de primer orden y de los posibles fenómenos de cabalgamiento, así como de la existencia de series deslizadas. Estos factores, por ejemplo, han sido de primordial importancia en las investigaciones hidrogeológicas realizadas en el Sur y Sureste de España.

c) Datos hidrológicos

El poder disponer de datos hidrológicos lo más completos posibles es factor de primordial importancia para el estudio hidrogeológico de una región.

Se deben tomar datos de todos y cada uno de los alumbramientos y manantiales de la región, y estos datos habrán de referirse a más de una época del año, con objeto de eliminar en lo posible los efectos de las variaciones estacionales.

Habrán de comprender, por lo menos:

Denominación, situación, cota y características de la obra.
Nivel hidráulico subterráneo.
Nivel estático (piezométrico).
Nivel dinámico.
Depresión.
Caudal.
Rendimiento específico.
Dirección de entrada del agua.
Naturaleza de la roca ..... (a - estéril / b - acuífera)
Temperatura del agua.
Salinidad y análisis químico.
Porcentajes relativos de aniones y cationes.

La combinación de estos datos hidrológicos, debidamente superpuestos a los planos geológicos, deberá permitir obtener, entre otras representaciones de interés:

Mapas del nivel hidráulico subterráneo.
Líneas isohipsas del mismo.
Mapas y líneas del nivel piezométrico.
Mapas de índices de salinidad y de variación relativa del mismo.
Mapas de caudales y de capacidades de producción,
etc., etc.

d) Mediciones geofísicas

Como hemos dicho, las mediciones geofísicas constituyen un elemento auxiliar de gran valor para las investigaciones hidrogeológicas. No todos los métodos son aplicables en cada caso, y algunos de ellos resultan en ocasiones incluso de costo prohibitivo. La elección del método geofísico más adecuado puede influir grandemente en el éxito de una campaña de investigación de aguas subterráneas.

Los procedimientos geofísicos más usuales son los siguientes:

$d_1$) Prospección geofísica aérea: Utilizando los métodos magnético, electromagnético y radiactivo (en general su utilidad se establece por este orden), pueden obtenerse buenos resultados en el reconocimiento general previo de grandes extensiones.

$d_2$) Métodos eléctricos: Por su reducido costo y fácil desplazamiento, son los más utilizados en las investigaciones de aguas subterráneas, y deben emplearse en la mayor parte de los casos.

$d_3$) Métodos gravimétricos: Adecuados como método auxiliar en el estudio de grandes cuencas o cuando las diferencias de densidad entre diferentes formaciones son muy acentuadas.

$d_4$) Métodos sísmicos de reflexión y refracción: Utilizables en grandes proyectos. Su aplicación a grandes profundidades y su elevado costo limitan considerablemente su empleo.

$d_5$) Método magnético terrestre: Empleado generalmente como complemento de las mediciones geofísicas por los métodos gravimétrico y sísmico.

$d_6$) Métodos radiactivos: En ocasiones se emplean trazadores radiactivos en la determinación de las vías de circulación y velocidad de las aguas subterráneas. Aplicables en las testificaciones de sondeos.

$d_7$) Otros métodos: Existen técnicas geofísicas recientes en vías de ensayo, entre ellas pueden citarse los sistemas de polarización inducida y los métodos eléctricos de frecuencia variable.

3) Concepto y determinación de cuenca hidráulica subterránea - Balance hidráulico

La determinación de cuenca hidráulica subterránea encierra conceptos de cierta complejidad, pero constituye factor de primordial importancia para el conocimiento de la hidrología subterránea de una región.

El estudio de las cuencas hidráulicas subterráneas permite determinar la capacidad de producción de agua de una zona, sin detrimento de las labores o manantiales existentes, y permite asímismo disipar el recelo, desgraciadamente tan extendido, de que toda labor de captación de aguas subterráneas produce una merma automática en la circulación de aguas superficiales del país.

Es la cuenca hidráulica subterránea un factor fisiográfico y topográfico que puede en cierto modo definirse como la zona en cuyo interior se acumulan, o a cuyo interior circulan, las aguas subterráneas infiltradas en su superficie.

Evidentemente, no tienen por qué coincidir sus límites con los de las cuencas topográficas, ya que la circulación subterránea depende, además de de la pendiente natural, de las características litológicas de las formaciones y de su disposición tectónica.

Claro está, que en los caudales subterráneos no interviene únicamente el agua procedente de la infiltración directa. Existe también la aportación subterránea procedente de la descarga de otras cuencas limítrofes, la infiltración indirecta procedente de la escorrentía, la infiltración indirecta, en zonas cultivadas, del excedente de agua de riegos, etc. etc.

Desgraciadamente, no disponemos aquí de espacio suficiente para el análisis detallado del problema, por lo que habremos de limitarnos a exponerlo en sus términos más generales.

Conocidas las características geológicas e hidrológicas de una cuenca y delimitados los bordes de la misma, puede determinarse el volumen anual de aportación a su interior, y, en consecuencia, su descarga y su capacidad de producción. Como hemos dicho, intervienen en este cálculo una serie de factores complejos, y los resultados serán tanto más exactos cuanto mayor número de estos se tenga en cuenta.

Sin embargo, desde un punto de vista práctico, y para el estudio previo de una región, puede simplificarse el problema, dentro de límites aceptables.

A estos efectos, creemos útil reproducir como ejemplo el cálculo de la recarga de una cuenca según el método utilizado por el Instituto Geológico en sus investigaciones en España. Se trata de una cuenca hidráulica subterránea en el término de Mazarrón, Provincia de Murcia.

| Zona | Superficie ($m^2$) | | Lluvia ($l/m^2$año) | | % Infiltrado | Litros año infiltrados | | l/s en la zona | |
|---|---|---|---|---|---|---|---|---|---|
| | Montaña | Llano | M. | Ll. | | Montaña | Llano | M. | Ll. |
| 1 | 10.188.750.000 | - | 325 | - | 65 % | 6.622.000.000 | - | 210 | - |
| 2 | 2.388.750.000 | 284.375.000 | 325 | 175 | 55 % | 1.313.000.000 | 156.000.000 | 42 | 5 |
| 3 | 520.000.000 | 1.706.250.000 | 325 | 175 | 45 % | 234.000.000 | 767.000.000 | 7 | 24 |
| 4 | 113.750.000 | 65.625.000 | 325 | 175 | 25 % | 28.000.000 | 16.000.000 | 1 | 1 |
| 5 | 7.426.250.000 | 1.071.875.000 | 325 | 175 | 5 % | 371.000.000 | 53.000.000 | 12 | 1 |
| | | | | | | | Total ... | 303 l/s | |

La recarga de la cuenca nº 3 es de 303 litros por segundo.

Las aguas subterráneas tienen un área de recarga, un área de circulación y un área de descarga. Dentro de cada cuenca la recarga es evidentemente igual a la descarga. Aquella, como hemos dicho, proviene de la lluvia y otros meteoros, de la descarga de otras cuencas, y de la infiltración de corrientes superficiales, de escorrentía y de riegos. La descarga se realiza por labores de captación manantiales, evaporación (incluída capilaridad), o por desagüe en otras cuencas hidráulicas subterráneas, o incluso directamente en el mar.

El balance hidráulico de una cuenca se establece por la ecuación:

Aportación = Infiltración más Escorrentía más Evaporación.

El manejo adecuado de todos estos conceptos permitirá en cada caso regular la extracción de agua subterránea de cada cuenca de tal modo que no se produzcan interferencias entre las labores existentes, ni con los caudales en estiaje de los manantiales de la misma.

(4) Labores de investigación y captación de aguas subterráneas

En esencia, consisten estas labores en la perforación de sondeos, o en la construcción de pozos y galerías. Por falta de espacio, no consideramos aquí las labores, muy interesantes, que pueden realizarse en algunos casos para conducir o detener artificialmente la circulación de aguas subterráneas.

Tampoco es este lugar para insistir en la descripción de los diferentes métodos de perforación de sondeos o de construcción de pozos y galerías.

En lo que a la perforación de sondeos se refiere, es conveniente que el diámetro inicial de los mismos sea suficiente para permitir la instalación en su interior de una bomba vertical sumergida.

Previamente a la colocación de la tubería de revestimiento, deben realizarse, siempre que ello sea posible, ensayos de testificación eléctrica. Ello permite obtener datos muy valiosos en cuanto a litología, porosidad y permeabilidad de las formaciones geológicas atravesadas, y resulta poco menos que imprescindible para establecer con seguridad las necesarias correlaciones entre sondeos perforados en una misma zona.

En muchos casos, y especialmente en formaciones calizas, es conveniente llevar a cabo pruebas de estimulación para aumentar los caudales obtenidos en los sondeos.

Estas estimulaciones pueden conseguirse mediante acidificaciones, o bien por fracturación hidráulica, combinada frecuentemente con la adición de elementos (arena, cáscara de nues, bolas de plástico o aluminio, etc.) que ayuden a mantener abiertas las fracturas producidas.

En cuanto a la perforación de pozos o galerías, la aplicación de las técnicas actuales de construcción resuelve los problemas en la inmensa mayoría de los casos.

Bástenos insistir únicamente en una precaución que no siempre es tenida en cuenta. En la perforación de galerías directamente emboquilladas en la superficie, y que hayan de penetrar en los niveles acuíferos atravesando diques impermeables, cabe la posibilidad de producir un desagüe inmediato de estos acuíferos si no se toman previamente las precauciones necesarias. Aconsejamos el reconocimiento previo de los referidos niveles, con sondeos o pozos, y la construcción de las galerías de tal modo que puedan estas cerrarse inmediatamente después de alcanzado el acuífero, regulándose entonces la extracción mediante válvulas o compuertas.

5) Resultados obtenidos en el Sudeste Español - Programa en Curso

Tradicionalmente han venido realizándose investigaciones de aguas subterráneas en el Sur y Sudeste de España, en cuyas investigaciones han participado, preferentemente, el Instituto Geológico y Minero de España, y el Instituto Nacional de Colonización. En los últimos 3 años estas investigaciones se han incrementado extraordinariamente y se han emprendido estudios hidrogeológicos completos de todas las provincias que constituyen la "España seca", es decir, el Sur y Sudeste de la Península.

Estos estudios se realizan siguiendo, en líneas generales, los métodos expuestos en las páginas anteriores.

Está ya terminado el estudio hidrogeológico de la Provincia de Murcia, y muy avanzado el de la Provincia de Córdoba.

Los equipos del Instituto Geológico y Minero de España están actualmente trabajando además en el estudio de las Provincias de Almería, Granada, Jaén y Málaga, y se espera que este trabajo quede terminado en un plazo de dos años. A continuación, se emprenderá el estudio de las Provincias de Castellón, Valencia, Alicante, Sevilla y Huelva, con lo que debe esperarse que en un plazo de 5 años quede terminada en su fase de estudios previos la investigación hidrogeológica de la totalidad del Sur y Sudeste de España.

Como consecuencia de todas estas investigaciones, se obtiene la localización de las labores de captación para nuevos alumbramientos de agua subterránea. Una parte de las labores se van realizando simultáneamente con las investigaciones, conforme progresan éstas, pero la mayor parte habrá de llevarse a cabo una vez quede terminado el estudio de cada Provincia.

Ello no obstante, los resultados positivos que se están alcanzando en las labores de captación son ya muy alentadores.

El caudal subterráneo alumbrado en conjunto en España en los últimos años es ya superior a la cifra de cinco mil litros por segundo cada año, y es de esperar que estas cifras aumenten muy considerablemente, conforme vayan progresando los estudios hidrogeológicos provinciales que antes hemos mencionado.

Simultáneamente con estas investigaciones se realizan trabajos de control y de regulación de las cuencas subterráneas actualmente en explotación.

Madrid, Agosto de 1962.

EL INGENIERO DE MINAS

1123 S - Nov.1962 - 600

E/CONF.39/A/176
26 Oct.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.5.1.3

India

# MINING LEGISLATION

By H.R. DEWAN,
Director, Indian Bureau of Mines,
Ministry of Mines and Fuel,
India

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

## NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

# MINING LEGISLATION

by

DEWAN, H.R.

DIRECTOR, INDIAN BUREAU OF MINES
MINISTRY OF MINES AND FUEL
INDIA

## INTRODUCTION

1. From the time the ownership or rights of the rulers were established on agricultural and other lands, it was customary to levy and collect certain specified share of produce or yield from forest lands, tanks, canals, rivers and agricultural lands. With the advancement of knowledge and along with the day to day refinement and improvements in living standards, a great number of articles made out of a vast number of different substances came into daily usage. Perhaps the earliest uses of mineral by mankind were the primitive implements made out of agate, flint, pitchstone, etc. In those days, everybody was at liberty to search and made use of these minerals without any restrictions, i.e. the discoverer had the right to a "claim".

2. From this stage, man has steadily advanced in the art of employing minerals for innumerable uses. In fact, to-day, we have become so much dependent on mineral products that the very existence of civilisation without them may be considered impossible, for they provide us with the materials for building a humble dwelling or sky scrapers, domestic appliances, agricultural implements mineral fertilizers, lighting and power, means of transport on land, sea and air, and a large variety of implements, tools and machineries used both in peace and war, besides serving as a medium of exchange of singular importance in international credit and national stability. Thus minerals have played an ever-increasing role in world affairs, and today a fervent search is being made all over the world for uranium and other atomic minerals to manufacture nuclear weapons for war purposes and to utilise atomic energy in peace.

3. Even before the industrial era, India is said to have been one of the most important centres of trading for pearls, diamonds, gold, emeralds and sapphires. It is said that before 1856 all the diamond wealth of the world originated from India. The export trade of these previous articles attracted the attention of the West and created an irresistible lure to trade and to acquire such interest. This craving profoundly affected the trend of history by encouraging exploration, inciting conquest and promoting spread of civilisation. Colombus while attempting to find a sea route to India discovered America.

4. Mineral development has become an essential factor in the economic and industrial advancement of a country, and therefore it is necessary to define the proprietory rights of minerals and the rights of those who choose

to exploit them, through proper mining legislation. However, the enactment of laws has to be a continuing process so as to take account of the new factors brought into play by changing social, economic, industrial and scientific advancements.

## AIMS AND OBJECTS OF MINING LEGISLATION

5. (a) To identify the proprietory mineral rights of the individuals or the State.

(b) To define the status of the prospector or the lessee.

(c) To safeguard his rights of possession during prospecting and mining operations.

(d) To give him the right to extract and acquire title to the Mineral extracted.

(e) To lay down a procedure for acquiring and perpetuating such title.

(f) To define his obligations regarding operation and scientific development of the mines.

(g) To specify the conditions in respect of area of lease hold, period of lease, and rate and mode of payment of rents and royalties.

(h) To avoid conflict and preserve public order in the event of a rush of prospectors to the newly discovered mineral prospects.

(i) To regulate and control the development of mines and minerals.

(j) To restrict in public interest the prospecting or mining of certain minerals by private persons.

(k) To prescribe methods of mining or extraction and the limitation or prohibition of such methods.

(l) To promote safety, health and welfare of mine-workers.

## THEORY OF MINERAL AND MINING CONCESSION RULES

6. The fundamental principle of any mineral concession rules is that some individual or corporation who does not own the mineral in place may intend working the mineral in that property and acquire a title to the mineral so extracted. The Mineral rights may belong to the State (Crown) or to a private owner. The stipulation under which such an individual or corporation may be allowed to prospect or work the property for one or more minerals forms the basis of mineral concession rules.

(a) In the early days when the use of minerals was not widely known or when the properties were not properly settled, any person who discovered a mineral prospect had a claim to work that property. This is known as the 'Claim System'. Under this system, too, in order to preserve public order and to avoid conflicts between the different claim holders some arrangements became necessary to demarcate the areas of their claims and to determine conditions under which they could hold their claims.

(b) The State or the owners of mineral rights at their discretion may grant prospecting licences or mining leases under specific conditions. This is known as 'Concession System'. Under this

system the operator (lessee) secures right to extract and to acquire title to the mineral extracted, as long as he fulfils the specified conditions. The lessor has the right to certain rents and royalties and to demand a reasonably uninterrupted and workmanlike performance of operations.

## ROYALTY

7. As used with mining, royalty may be defined as the payment to the owner of mineral rights for the privilege granted by him for exploiting the mineral. Originally referred to the Crown owner-ship and the granting of concessions on the basis of a payment to the royal owner for the mineral produced by the concessionnaire.

8. Minerals while underground have no market value, but they have potential value. When a mineral has been extracted it acquires a definite value according to its grade and its demand in the market. Therefore, when the mineral property is leased out by the owner, he does so in consideration of payment of share of the value which the mineral acquires after its extraction. This is known as "royalty".

9. Sometimes a lump sum amount known in India as "Salami" used to be paid by the lessee in consideration of grant of such concession, and only a nominal rate of royalty, irrespective of the value of the mineral was fixed for annual payment.

10. Mineral rights are not vested in the lessee but he has the right to extract and to acquire a title to mineral so extracted, subject to payment of royalty and fulfilment of other conditions of the lease covenant during the period of lease. Royalty, therefore, is a first charge on operating profits and is an item of cost to the operator.

11. From the lessor's point of view, royalty may be considered as his sale price of the mineral leased out and represents partly a return on his depleting capital (Mineral property). Therefore, it is essential that a correct assessment of a mineral deposit including its economical workability be made to arrive at an appropriate rate of royalty.

12. The basis for calculating the royalty so far has been the pit mouth value of the mineral i.e. the highest price at which the mineral can be sold at the mine. If the mineral has no local market the pit mouth value can be worked back from the final sale value at the market by deducting transport, handling, dressing, processing and other incidental charges.

## DEAD RENT (Minimum royalty)

13. Usually a minimum rent per unit area leased out is fixed which the lessee has to pay to the owner on the total area leased out. This is based on the assumption of certain minimum yearly production. Sometimes a lump sum may be fixed on a similar assumption. The underlying principle of fixing a Dead Rent or Minimum Royalty is that the lessor is assured of reasonably constant performance of effective operations so that his capital represented by property shall not be unduly idle, and it accrues a minimum return. Therefore, when the royalty computed on the production exceeds the Dead Rent, only royalty becomes payable and not both. High rate of Dead Rent tend to discourage unnecessary blocking of large mineral areas under one lease, while it encourages selective mining and "picking out the eyes" of the deposit.

## RIGHTS AND PRIVILEGES OF THE LICENSEE/LESSEE

14. The grant of a prospecting licence or a mining lease confers the sole

right on the licensee or the lessee to undertake prospecting or mining operations on the specified lands subject to the terms and conditions stipulated therein for a specified period. The licensee is entitled to carry on essential works such as clearing of shrubs, digging, pitting, trenching, boring, erection of machinery, collection and despatch of samples for analysis and testing etc. needed for prospecting in a reasonable manner. Further he enjoys the right, subject to certain conditions, to transfer the ownership and to extent the period of the licence and above all in certain countries has the preferential right to obtain a mining lease in respect of the whole or a part of his prospect.

15. The mining lessee besides his prospecting rights, has such other rights as to win, beneficiate and carry away the minerals, to sink shafts, inclines and tunnels etc., to make roads, to get building and road materials, to use water, to use land for mining and other related purposes, to make use of timber standing on the land without any unlawful interruption from the lessor or the State. The mining lessee generally has an option to renew the lease subject to certain conditions and the right to determine the lease anytime after giving due notice and thereafter to claim refund of his security deposits and remove his movable property. He also generally has the right to hearing prior to promulgation of orders and judicial review of administrative decisions.

## PROCEDURE FOR ACQUISITION AND PERPETUATION OF SUCH TITLES.

16. Different procedures are followed in different countries for the grant of mineral concessions, except for certain limitations, a principle of first come first served is generally followed. In the "Claim" system a discovery of the mineral must be made in order to get the concession for that mineral over that area. In such a case the "Claim" is required to be registered with the proper authority on payment of prescribed fee, who after varification of the authenticity of the claim and fulfilment of specified conditions by the applicant may grant a concession over that area within the prescribed maximum size limits. In the "Concession" system, applications for the grant of mineral concessions are required to be submitted along with the prescribed fee by persons satisfying the prerequisites in respect of nationality, financial status mining experience, Income-tax clearance etc. to the prescribed authority, who may grant the concession either in part or in full. After the concession has been granted, the area applied for is surveyed and demarcated by the prescribed authority usually at the expenses of the applicant and a formal contract in the form of licence or lease is executed by both the parties. The Concessionnaire or the Lessee has to make a security deposit for the due performance of the contract. Generally a person holding prospecting licence over the area has a preferential right to obtain a lease over that area. In India a person applying for prospecting licence or a mining lease must have a certificate of approval. Any person who is an Indian national can obtain a certificate of approval on payment of fee of Rs.500/- from the State Government concerned. A person who is not an Indian national may also be granted a certificate of approval on the payment of prescribed fee but only with the approval of the Central Government.

## OBLIGATIONS OF THE LESSEE

17. The foremost obligations of the licensee/lessee are to carry on work in a systematic, scientific and workman-like manner, to maintain correct and faithful account of all prospecting work done, expenses incurred and of production, despatch and sale of minerals, payment of royalties and compensation for damage to the land surface at such rates and at such times and in such manner as may be specified, and to indemnify the lessor and/or the State against all kinds of third-party claims and to comply with all labour legislation and mining laws, rules and regulations made thereunder for the purpose of regulation, conservation and development of mines and minerals.

and to ensure safety, health and welfare of mine-workers. Usually licensees/ lessees must within a specified time commence work and continue without long interruption. They may in certain cases be required either to incur a certain minimum amount of expenditure or to complete a specified amount of work. They are also prohibited not to exploit minerals other than those specified in the lease.

18. In many countries such conditions are imposed on the prospecting licensee that he cannot exploit the mineral deposit otherwise than by taking out a mining lease. Also licensee/lessee is generally obliged within certain time-limits to intimate the start of prospecting/mining operations, to report the discovery of minerals not covered in the concession, to furnish certain geological and geophysical information, to submit a report on the results of prospecting to the lessor and the state and to render the area safe, and harmless on abandonment of prospecting/mining operations or determination of the licence/lease. A licensee/lessee is also required to intimate the commencement of any prospecting and/or mining operations such as drilling boreholes, shaft sinking etc. revealing exploratory information, to keep full records of the strata passed through, to preserve drilling cores, samples etc. for a certain period, to make provision for weighment and/or measurement of minerals produced and to allow the entry for inspection, measurement sampling etc. by State officials for the purpose of enforcement of various rules and regulations. The Licensee/Lessee is also duty bound not to obstruct prospecting and mining of other minerals not specified in his contract. He is not allowed to have his operations financed and controlled by any other individual except with prior approval and to give reasonable facilities of access to the neighbouring concessionaires on payment of compensation. Also a concessionaire has to reimburse all expenses that the state and/or lessor may incur in respect of certain essential works which the concessionaire may have neglected to do.

19. In addition a mining lessee has the further obligations to keep boundary marks in good condition for demarcation purposes, to maintain uptodate plans of mine workings, to strengthen or support any workings under any public works such as railways, roads, canals, reservoirs etc., to secure and keep in good condition pits, shafts workings etc. during the subsistence of the lease and to hand them over in good condition on termination of the lease. They are also required to submit periodical reports on the progress made and the future development programmes and to grant practical training facilities to students of mining and geological institutions approved by the State. Certain notices and returns in respect of commencement of surface and mining operations, temporary discontinuance and permanent abandonment, employment of certain officials, change in name or nationality of certain employees or the concessionaires, production, sale and despatch of minerals etc. have also to be furnished by the lessee.

## RIGHTS AND PRIVILEGES OF THE STATE

20. In order to ensure that the lessee enjoys his rights and discharges his obligations the State has to assume certain powers, rights and privileges in the public interest.. They are enumerated below:-

i) Avoidance of conflict and preservation of public order in the event of rush of prospectors.

ii) Right to inspect for the purposes of regulation, control and development of mines and minerals, safety, welfare and health of mine workers.

iii) To restrict in the public interest, the prospecting or mining of certain minerals by private persons.

iv) Regulation of mineral development by foreign nationals.

v) To specify the conditions in respect of area of leasehold, period of lease, and the rate of and mode of payment of rents and royalties.

vi) Right of pre-emption in times of emergency.

ROLE OF MINING LEGISLATION IN THE FORMULATION OF A SOUND MINERAL POLICY

21. Regulation affecting local and foreign investment:- Present day large-scale industrial development is based fundamentally on the production of mineral raw materials in adequate quantities, which, requires increased capital investment in the mining industry. By its very nature of being dependent on continuously depleting assets, some of the factors to be considered by an enterpreneur for investing his capital in mining are quite different from those in case of any other industry. Further a higher risk is usually involved in mineral investment due to uncertainty about geological conditions affecting mineral reserves and their grade, future cost of production particularly in new isolated areas, percentage recovery of associated minerals and by-products, the life of the mine in relation to amortisation of capital, the competitive position of the mine which may be weakened by the discovery and development of more favourable deposits by more efficient new methods of mining, milling and smelting etc. using better machinery and the price fluctuations so common to mineral markets. Also the complex nature of the plant and machinery used by the mining industry results in large capital investments. These tend to make the return on capital uncertain.

22. Usually it takes a very long time (ranging from 5 to 7 years or even more) to explore, prospect and develop a mineral deposit in order to bring it to a production stage and sometimes all this work, carried on at a considerable cost, may result in nothing worthwhile. Mining investments are inherently inflexible and involve comparatively dangerous operations. Thus mineral production requires a particularly long term planning and long periods of execution. On account of these factors mining investors expect, and deserve, better and quicker returns on their capital. The achievement of this object can be aided through legislation for the provision of subsidies, relief in taxation by grant of increased depreciation and depletion allowances etc., development rebate, grant of commercial protection etc., if adequate capital is to be attracted to this indispensable industry. Alternatively, the State can itself undertake its development.

23. The majority of under-developed countries have launched planned programme of economic development with a desire to make rapid progress to catch up with the rest of the world. This lays down heavy responsibilities on the State which may even have to invest its own funds to achieve its objectives. Statistics show that the share of the State in the new investments throughout the world has varied between 13 and 47 percent in various countries for the period 1950-54, whereas in 1957 it varied between 20 and 58 percent indicating a clear trend towards greater participation by the State in industrial investments in all countries of the world. Emphasis may either be laid on the state or on the private sector or it may be laid equally on both depending upon the general policy of the country but generally State control is maintained to a greater extent over minerals of strategic importance. The mining legislation should, therefore, be suited to conform to the policy of the State and in cases where private sector is expected to play any major role in the development of mineral resources, it is obviously desirable to create by legislation a favourable atmosphere for creation, deployment and amortisation of investments. Further whatever be the mineral policy of the State, it is obviously desirable to enunciate it clearly through public pronouncements particularly in respect of nationalisation and controls over their production, quality and marketing, export and import etc. for the guidance

of the enterpreneurs and to allay any fears or doubts that may arise in their minds.

24. Special legislative measures may be necessary for encouragement of foreign investments which may include favourable provisions for repatriation of income and capital, relief from double taxation, reasonable guarantees against nationalisation for sufficiently long periods and payment of fair compensation in cases of compulsory acquisition, etc. It is desirable that as far as practicable such foreign capital is utilised for the development of mineral industries capable of saving foreign exchange either through export earnings or import substitutions. Obviously its partic'pation in the development of basic essential or strategic minerals is required to be kept under strict control of the State.

25. Effect of Nationalisation:- There are many generally accepted arguments in favour or against nationalisation but greater need and urge is felt for nationalisation in underdeveloped rather than in industrially advanced countries. Also increasing State control of private investments, particularly that of foreign capital is usually justified on account of the general cost-benefit consideration, fixation of priorities, its effect on the country's balance of payments, its control over the development of key or strategic minerals and the need for planned economic development so that there is a balanced growth of economy most efficient utilisation of capital resources and avoiding duplication or overlapping of efforts. The fear of sudden nationalisation hampers the growth and efficient working of private sector and therefore, if private sector has to play any part in the industrial activities of the nation (and there is no reason why it should not help in the task of nation building), then it is necessary for the State to enunciate its policy in this respect in clear terms. The development of those minerals which cannot very well be carried out by the private sector, for various reasons, should of course be given priority in the programmes of the public sector undertaking to form a well integrated development plan. It is also true that policies of any State cannot remain stagnant for a long period but in cases where compelling circumstances do necessitate nationalisation of any particular industrial unit, the law of the land should provide for payment of reasonable compensation determined by impartial authorities. Also the law has to protect the rights of the State to bring about such necessary changes in the degree of control of any unit in the public interest as may be considered necessary from time to time.

26. Regulation of production:- Regulation of production by the State through legislative controls is inevitable to achieve a planned economic development. Need for regulation of production may also arise from strategic considerations, lack of adequate known resources of particular minerals, need for conservation of mineral resources for future use and to balance outputs of particular type or quality of minerals according to their consumption in certain selected industries etc. For example, in India known resources of coking coal are very limited compared to those of iron ore, therefore, a need has been felt to peg the production of coking coal to the requirements of the existing metallurgical plants in that country. Similarly minerals of strategic importance of limited known reserves may be subjected to production controls, all the more so when they are likely to be required in substantial quantities in the near future for the indigenous industries.

27. Grading and marketing:- Mineral resources may be developed either to meet the local indigenous demands or for export with or without any treatment, concentration etc., or for both. Production of finished, or semi finished products from minerals permits the full benefits such as employment opportunities development of subsidiary industries, considerable enhancement of value

and steady market demands etc. In an under-developed country on the threshhold of economic and industrial progress, the capacity to earn foreign exchange to export of finished products is small and the need to import capital goods is great and therefore to maintain a proper balance of foreign currency earnings and payments, this gap can only be filled by export of raw materials judiciously selected for the purpose, keeping the present and future local needs in view. Many a times, it becomes essential for the law to stipulate, introduce and enforce strict quality control to ensure that sub-standard minerals are not supplied either for the internal market thereby lowering the efficiency of production units and the quality of their products or for export. In order to keep up the exports and yet use our mineral resources to the fullest possible extent, lower standards of quality may be set for internal than for external markets in order to conform to the international standards or as an inducement for capturing an important market.

28. Conservation of mineral resources:- Mineral resources are wasting assets and yet modern civilisation is making more and more use of minerals necessitating a continuous increase in their production. Therefore, enforcement of conservation measures are essential not only in the interest of a particular nation but that of whole mankind. These conservation measures may provide for the systematic exploration, prospecting, mining, milling, concentration, beneficiation etc. by scientifically efficient methods, obtaining the maximum possible recovery of the subsidiary associated minerals, blending of ore, substitution of some high grade minerals by other synthetic products or lower grade minerals for certain purposes, grant of subsidies and allowances and most fruitful use of the minerals in general. Although selective mining of high grade minerals only may yield spectacularly high profits, generally it leads to lowering of valuable reserves and hence may not be beneficial from an over-all national point of view. Valuable by-products, although economically recoverable, may not be recovered by the mineowners either because of inability or unwillingness to invest additional capital or because of the possible resultant decrease in rates of profits. Mineral legislation generally empowers the State to enforce such measures as and when considered necessary.

29. Export - import policies:- Export - import in relation to minerals is deeply related to the foreign exchange balance position of the country and other economic considerations, mineral conservation policies, strategic considerations, and known resources of minerals etc., all of which are liable to change from time to time. Therefore, this policy has to be formulated for short periods only at a time and may provide for restrictions on import or export, levy of duties on imported or exported minerals and protective tariff. The main object is to encourage development of indigenous industries either for export promotion or for import substitution by, if necessary protecting them from competition with imported material particularly during the initial stages or rendering them assistance by way of reduction in railway freight, royalties and export duty or cesses and payment of subsidies to become competitive in price and quality in any or all foreign markets. Thus the role of mining legislation is very important for a sound mineral policy of any country and particularly under-developed countries.

## SURVEY OF MINING LEGISLATION IN INDIA

30. History of mining legislation in India:- Minerals like gold, copper, iron, salt were worked in India even before the time of Ramayana and Mahabharata (Indian epics). Certain stipulations and conditions were laid down by the Rulers (Rajas and Tribal Chiefs) for the working of mineral properties who had mineral rights in their respective territories. They collected royalty either as a share of the minerals produced as in the case of precious

stones and diamonds or purchased the entire mineral at a specified rate from the miners and sold to the consumers at higher price, as in the case of salt. Mineral rights belonged to the Rulers and they had some system of contract with the operators for receiving rent or royalty.

31. By permanent settlement (Regulation 1 of 1793) the mineral rights were vested in Zemindars or land-holders. The Government took no legal power for the regulation of work in the mines or for the inspection of mines, to require notice to be given of the occurrence of mine accident and the protection of the miners or to regulate the employment of women and children on underground work or in respect of work which may be dangerous or unsuited to their age or sex. The first measure to classify and bring this subject into conformity with the growing needs of the country was taken on 22nd March, 1901 when an Act providing for the "Regulation and Inspection of Mines" was promulgated. This was known as the Indian Mines Act 1901 (Act No. VIII of 1901) the jurisdiction of which extended to the whole of British India including British Baluchistan the Santhal Parganas and the Pargana of Spiti. This act was amended in 1923 and further amended as Mines Act XXXV of 1952.

32. The first attempt to bring the terms of contract and lease governing the working of mines and minerals situated in State lands was attempted during 1894 when rules for the grant of Exploring and Prospecting licence and mining leases by local Governments were promulgated by the Government of India. These rules were revised in 1913. Certificate of approval, prospecting licence and mining lease were incorporated and exploring licence was discontinued. In order to provide for the regulation of mines and oil fields and for the development of minerals, Mines and Minerals (Regulation and Development) Act, 1948 was passed by the Dominion Legislature and it received the assent of the Governor General on the 8th September, 1948. This Act was substituted by Act 67 of 1957. This Act is very comprehensive. Mineral Concession Rules, 1960 and Mineral Conservation and Development Rules, 1958 have been framed under this Act. The Mineral Concession Rules provide for the manner and the persons by whom the certificate of approval, prospecting licence and mining lease can be obtained, whereas the mineral conservation and development rules provide for scientific development and mining of mineral deposits and conservation of minerals.

33. To suit the changed conditions after independence several Acts have been passed and rules framed thereunder. The following are some of the important Acts and Rules:-

(a) Mines Act, 1952:

- (i) Mines Rules, 1955.
- (ii) Mines (Posting up of Abstracts) Rules, 1954.
- (iii) Indian Coal Mines Regulations, 1957.
- (iv) Indian Metalliferous Mines Regulations, 1961.
- (v) Coal Mines Rescue Rules, 1939.
- (vi) Coal Mines Pit Head Bath Rules, 1946.

(b) Coal Mines (Conservation and Safety) Act, 1952.

- (i) Coal Mines (Conservation and Safety) Rules, 1954.

(c) Coal Grading Act, 1925.

(d) Mines and Minerals (Regulation & Development) Act, 1957.

- (i) Mineral Concession Rules, 1960.
- (ii) Minerals Conservation and Development Rules, 1958.

(e) Coal Mines Labour Welfare Fund Act, 1947.

(i) Coal Mines Labour Welfare Fund Rules, 1949.
(ii) Coal Mines Labour Welfare Office Establishment (Contributory Provident Fund) Rules, 1951.

(f) Mica Mines Labour Welfare Fund Act, 1946.

(i) Mica Mines Labour Welfare Fund Rules, 1948.
(ii) Mica Mines Labour Welfare Office Establishment (Contributory Provident Fund) Rules, 1950.

(g) Iron Ore Mines Labour Welfare Fund Act, 1960.

34. The Mining and Mineral legislation in India is very comprehensive and covers the entire field for working of mines and minerals including atomic minerals, oil fields and safety, health and welfare of workers.

## CONCLUSION

35. Enactment of Mining legislation in India dealing with minerals and labour employed in mines has been particularly adopted to the conditions prevailing there from time to time and is, therefore, a continuing process. Along with the industrial, economic and scientific advancement of the country, social changes in the life of the country are taking place from day to day which may necessitate amendments to the existing legislation or its extension to different areas and/or categories of persons or even enactment of new legislation. The Government and the people of India are quite alive of this and are anxious to see that the best standards of mining practices and labour welfare are attained in the shortest possible time.



1317 E - Nov.1962 - 1,600

E/CONF.39/A/177
26 Oct.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.2

UNESCO

# A MATHEMATICAL MODEL OF THE LOWER MEKONG BASIN

By D. ZANOBETTI,
Department of Natural Sciences,
UNESCO

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

## NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

# A MATHEMATICAL MODEL OF THE LOWER MEKONG BASIN

by

D. Zanobetti

Department of Natural Sciences, Unesco.

---

## I. THE MEKONG : PRESENT AND FUTURE

The seventh longest river of the world which has obscure sources from the snows of the high Tibet plateau and flows for half of its 4,000 kms. length in a valley less than 100 kms. broad, when reaching the border of Laos expands in all its majestic importance; the low-water discharge which is less than 600 $m^3/s$ at Luang Prabang and a little more than that at Vientiane, increases to about 1,000 with the apportion of the Mune, to 1,200 with that of the Sekong and surpasses 1,400 $m^3/s$ south of Kratie and at Pnom Penh. There the drainage area is already 600,000 $km^2$, although it will add a further 100,000 $km^2$ with the apportion of the Tonle Sap, that "Grand lac" which acts so happily as a natural and beneficial reservoir moderating its floods. There also, the discharge becomes comparable to those of the largest Asian rivers; 11,000 $m^3/s$ average, 39,000 at flood periods, the maximum estimated flood reaching 60,000 $m^3/s$.

Twenty million people live in its lower basin: two in Laos, seven in Thailand, five in Cambodia and six in Vietnam. The Mekong river is their father, everything comes from him: rice, maize and fish on which most of them live; in addition, it is their master road. But from it also come disasterous floods whose irregularity makes crops insufficient and uncertain and all life difficult.

What if the river might be regulated?

A dam at the Pamong gorges, 30 km above Vientiane, besides producing 400 MW of firm power would store 2 billion $m^3/s$ and provide a water level higher than any other in North-eastern Thailand. A continuous discharge of 200 $m^3/s$ for a period of four months would irrigate the dry Korat and Vientiane plains and permit navigation even during the dry period.

A dam at Khemarat 14 km upstream of the confluence with the Mune would store 5 billion $m^3/s$, in that way effectively moderating the flood discharge and increasing the low water level. A firm power of 1000 MW could also be generated.

At the falls of Khone a dam only 5 m high and a diverting channel would secure a drop of 30 m to generate 600 MW : there also navigation would become possible and vessels could proceed as far as Pakse.

At Sambor advantage could be taken of existing rapids upstream from Kratie for a dam to generate 500 MW and to irrigate 100,000 ha of fertile lands along both banks of the Mekong.

Finally a barrage on the Tonle Sap which connects the Mekong with the Great Lake would increase the latter's capacity as a flood reservoir and thus reduce the peak water level at Phom-Penh by more than 1 m, increase the low water discharge threefold, irrigate 150,000 ha of land, increase the rice production by 100,000 tons. But, we shall come back to this project later.

With these five works navigation would become possible all along the river with higher tonnage vessels; salt from the coast area of Vietnam where it can be produced as a small fraction of the production cost inland, could reach 10 million consumers without appreciably increasing its price; fish from the 'grand lac' could be distributed easily all over the country, thus increasing the advantage of fishing more and fostering the development of that activity which is essential in providing proteins to the whole region; timber from Laos where there are still 10 million hectars of virgin forest, could be transported downstream at tenfold or more the present rate, without the very high percentage of loss and pilferage now experienced.

Irrigation would increase enormously the cultivated areas and allow nobler and more valuable crops. Corn, cotton, tobacco would increase from their very low level production rates and rice itself could be obtained in better and higher priced qualities. To imagine the ratio of increase of production in terms of its value is something which has not even been attempted.

## II. THE LOWER MEKONG COMMITTEE

To regulate the Mekong is a huge project; four different countries are interested in the lower part of the river, but none of them, nor for that matter all of them together, could have the technical resources, not to speak of the financial resources necessary for such a huge project. It is for this reason that the United Nations, through its Economic Commission for Asia and the Far East, have taken into hand its operation. The Mekong is an international river and it is only proper that the most international of all the organizations should meet the great challenge : the importance of the task is worth the tremendous effort involved. Projects have begun to be studied as far back as 1953, but there have been so many studies on the Mekong that no single one can be hoped to produce any result. Only a joint effort can bring about a comprehensive master plan.

It is with this in view that the United Nations have helped the four riparian countries establish in 1957 a Committee for the Coordination of study in the Lower Mekong Basin, which is an extremely interesting organization whose success should be a lesson to many other parts of the world.

The Committee is an assembly gathering quite often, consisting of representatives of the four countries which by this means are themselves responsible for their actions and their future. Moreover, they are certainly more competent to solve all the problems other than purely technical ones than would be people from any other parts of the world. To this assembly a permanent organ has been provided by the United Nations: the Executive Agent, and to assist him, a three-member Consultative Committee. The Executive Agent and the Consultative Committee provide the technical and operational direction of the decisions taken by the assembly.

A number of smaller projects have been started: pilot projects - one in each of the four countries - but the main big projects, those connected with the construction of dams but by no means limited to it, with all the resulting annexes, are still in the study phase, and one of them, whose necessity has been felt vaguely and indistinctly by the populations themselves for centuries, has now come to a point of maturity such, that concrete action has been judged necessary. This is the Project of the Tonle Sap, which of all is perhaps the most promising whilst at the same time the most complicated.

## III. THE TONLE SAP PROJECT

At the beginning of the rainy season, the affluents of the Great Lake increase their discharge while carrying important solid content (which sometimes even obstructs them) and the lake itself discharges quietly through the Tonle Sap into the Mekong, which carries low floods.

Then the flood of the main river arrives: it is an impressive wave which in some places reaches a height of 14 metres. When this flood reaches Pnom Penh, the Great Lake has not yet been filled, so that water reverts its course back from the Mekong into the lake for most of the rainy season. Only after the end of the rainy season, when the level of the Mekong has sufficiently decreased, does the Great Lake discharge into the river and this goes on for half the dry season.

This regulating activity of the Tonle Sap is very important. One appreciates it when comparing the total volume stored in the lake, i.e. 40 billion $m^3/s$ with the total discharge of the river which is 400 billion $m^3/s$.

The low water discharge which we mentioned to be 1,400 $m^3/s$ per second at Pnom Penh, increases again to 2,000 $m^3/s$ after it, due to the natural discharge of the great lake and the regulating effect is even appreciable during the flood period.

The Tonle Sap Project consists of erecting a movable barrage in the Tonle Sap: the best place for its location is part of the problem, although it should not be far from Kompong Luong.

When, during the early part of the flood season the main river carries low floods, the Grand Lake could be kept at its lowest level by keeping the barrage closed, and preventing the river from entering it. Only after the Mekong had attained a prescribed level, would it be admitted into the lake by opening the barrage and this would result in a considerable cut-off of the flood peak. The lake itself would become much more effective as a reservoir and its accrued volume would increase the amount of fish. Towards the end of the flood period and during the whole of the dry season, intelligent operation of the barrage would release water with great benefit to irrigation and improvement of the navigation; it is estimated that the regulated discharge released from January to May would add more than 4,000 $m^3/s$ per second to the low water discharge, more than twice the present low water discharge of the Mekong.

The Tonle Sap Project has been studied quite extensively. Bulletin No.12 of the Flood Control series has given particular attention to the evaluation of the decrease of the peak flood and to the increase of the low water discharge. The Jamme Report has given consideration to the irrigation problem and has estimated at 40 per cent the mere advantage of making possible the cultivation of better rice qualities. It has also shown how the increase in the low water discharge during the dry season would push towards the sea the borderline of saline water, so that irrigation would become possible in regions where no cultivation of any importance has hitherto existed. This report is all the more interesting in that it deals in detail with the operation of the barrage and there we find an important scope for the construction of a model.

Again, the importance of a model in determining the correct operation of the barrage has been examined in the report by Bourrières-Paulsen and finally the Committee of the Mekong decided for the construction of the model.

Unesco immediately offered its assistance for this study and sent a 3-men mission in 1962 to study the problem of a model, on the site.

Models are a well-established means of solving hydraulic problems. However, in this case, one should think that from Battanbang to the sea there are 500 km of flooded country over a width of 200 km. Slopes at low levels from Pnom Penh to the sea are in the order of 1 cm and it would be extremely difficult to reproduce on a model these very small slopes, due to the intervening phenomena of capillarity and distortion.

A possible hydraulic model would have probably required a surface of at least one hectar with levels precise to 1/10 mm. This and many other considerations have led the members of the Unesco mission to decide on a mathematical model.

After this, action proceeded at an extraordinary speed which goes to the credit of the Agencies to which the United Nations have given the various tasks.

Unesco's mission was completed in September 1960. The report was appraised and approved by the Committee, a request submitted by the four riparian countries to the United Nations Special Fund in the same year. The Special Fund experts worked out the financial budget and the Consultative Board recommended the approval of the project by February 1961. Finally, the Governing Council of the Special Fund approved it by May 1961 and entrusted Unesco with the implementation.

The Department of Natural Sciences of Unesco immediately started preparing a Plan of Operation for the whole project and at the same time the search for a suitable laboratory which could be entrusted with the construction of the model began. A panel of consultants was also appointed: three hydraulicists and two mathematicians serve on it, contributing experience of four different countries. Seventeen laboratories were invited to submit a tender. Thorough examination of their proposals has led to the selection of one of them, well-known all over the world for its previous work in the same field. Eventually, the Plan of Operation and the contracts were signed, exactly one year after the date of the decision of the Special Fund and the same month the project was put into operation with the arrival of the first experts on the site.

## IV. UNESCO'S PROJECT

Although the most interesting thing may certainly be the way in which the United Nations have turned an international river into an effective testcase of international cooperation for the benefit of a far-distant region, it may be interesting to see also how the Project works.

Four phases are foreseen:

During the first phase, data will be collected both in Cambodia and Vietnam - records, maps, survey information will be reviewed and all useful information assembled and classified. This phase has by now been completed.

The second phase will consist of the preparation of a preliminary model, utilising all the data thus collected. With this model trial runs will be made to determine how accurately it reflects the natural phenomena; a certain adjustment will be possible for it in order to make it as accurate as possible. Its main purpose will be to see by how much the various parameters are important for its operation. It is for instance anticipated that changing the discharge of a certain tributary by an important amount may have a negligeable effect on the model and this will mean that the exact knowledge of that discharge is not important and the data on which this knowledge is based need not be checked. On the other hand, it is also foreseen that some data will be critical in the sense that their variation may considerably affect the model and this means that they must be known with sufficient accuracy to make the model really representative of reality.

The third phase will then be constituted by a measurement campaign to check all the data which have proved to be critical: discharges of some of the tributaries and at selected points of the river, levels in certain places of the Great Lake, rains, winds, evaporation, etc. This campaign of measurements will extend over a complete year and it is expected that it will be completed by the beginning of 1964.

Then will come the fourth phase consisting of the construction of the final model. The expected accuracy should make it possible to evaluate the water heights within the Delta plain with a precision of 10 cm and the rate of rise of the water with a precision of 1 cm per day at such places and times where they are considered to be of importance.

As soon as the model has proved to be faithful enough in its reproduction of the natural hydrography and other pertaining factors, its operation will begin as a permanent means to establish the advantages of erecting a barrage, where to locate it, how to operate it. It should be possible to determine the optimum methods of operation for the various conditions of flood and of low flow, considering all limiting factors such as the fisheries, navigation, irrigation, forestry, production of electric power. It should also be able to determine the magnitude of the hydraulic conditions which might cause damage should the barrage be incorrectly operated.

The model, to sum up, will become an invaluable tool to guide the comprehensive development of the whole Lower River Basin of the Mekong.

## V. CONCLUSION

Will the Project be successful?

To answer this we should first point out that it is the first time in the world that such a study is carried out in so vast a region with so many intervening phenomena. The project has been carefully studied and it should succeed, or at least it will provide the best possible results that modern techniques supported by adequate means permit.

The riparian countries are confident and all their technical personnel spares no effort in helping the international personnel involved in the Project, and as for the United Nations Organization, it should not be forgotten that their motto could be "We believe".

## BIBLIOGRAPHY


U.S. Department of Interior, Bureau of Reclamation: "Lower Mekong River Basin, A reconnaissance report", 1956.

U.N.,ECAFE: "Development of water resources in the Lower Mekong Basin", Flood Control series n. 12, Bangkok, 1957.

U.N.,T.A.A., "Program of studies and investigations for comprehensive development of the Lower Mekong River Basin" by U.N. Survey Mission (Wheeler), 1958.

id: "Development of inland navigation in the Lower Mekong Basin" by A.L. Van Riet, 1959

id: "Mineral resources development in the Lower Mekong Basin" by Marcel Schwob, 1959.

id: "Hydrometeorological investigations in the Lower Mekong Basin" by F. Grundy,1959.

id: "Flood control in the Mekong Delta with particular refernce to Viet Nam; Improvement of Drainage and Protection against Salt Water" by G.P. Jamme, 1959.

id: "Summary of findings and proposals on the economic develpment of the Lower Mekong Basin" by M.E.S. de Breuvery, 1959.

Mekong Committee: "First Report of the Advisory Board to the Committee for the Coordination of Investigations of the Lower Mekong Basin", by P. Bourrières, C.G. Paulsen, 1959.

UNESCO: "Mekong Delta Model, report of the preliminary Mission (Jamme, Bijker, Armaud)", 1960.




1353 E - Nov.1962 - 1,600

E/CONF.39/A/178
26 Oct.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A. 3. 3. 1

Federal Republic of Germany

# GEOHYDROLOGICAL GROUNDWATER INVESTIGATIONS IN NORTH-AFRICAN DESERT-REGIONS BY MEANS OF COMPLEX METHODS

By Georg KNETSCH,
Würzburg, Germany

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those

## NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

# Geohydrological groundwater investigations in North-African desert-regions by means of complex methods.

by
Georg K N E T S C H, Würzburg, Germany.

Since about 1960, an international team of geologists, geochemists and physicists, all of them members of scientific institutions of their home-countries (Egypt, Germany, USA) tried to investigate North-African artesian waters.
The author reports on the research work done by the team, mainly by Dr.K.O.MÜNNICH of Heidelberg, Dr.E.T.DEGENS, at present Pasadena, USA and by himself. Contributions of Dr.SHATA, Desert Institute, Cairo are taken into consideration. The investigations sketched below are in part still under way.
In many arid and semi-arid countries we know of reserves of subsurface waters, which can hardly be explained by recent rainfall. UNESCO reviews and papers deal with the problems for years, they can not be quoted here in detail.
The question whether such occurrences belong to "live"-systems or should be regarded as "fossil" (a "water-field" like an "oil-field") is a common problem.
Our idea was to solve this problem within a restricted area in combining "classical" geology (1)(2) with new scientific tools (3) and, international cooperation with scientists of the region in question. The investigations sketched below were subsidized by scientific institutions and the Egyptian Government. They are not concerned with uncertain statements of quantities available but concentrate on methodical questions of a diagnostical type. They comprise geological studies of potential infiltration times and -areas, of reservoir-formations, chemistry of the waters in question, age- and paleo-environment-determinations by means of $C^{14}$, Tritium, $O^{18}/O^{16}$-ratios etc.
The Sahara-portion around the West-Egyptian oasis-depressions has been tackled first and will be dealt with below. The water generally is tapped within such depressions, a peculiar cuesta-feature of the central and Eastern Sahara (4)(5). The water rests and migrates within a huge and complicated reservoir consisting of the Nubian Series (Paleozoic

to Lower Cretaceous).The complex consists of an intercalation of per=meable and impermeable beds.It crops out (Fig.I.,dotted area) in the Southern portion of our region,between the Sudan-frontier in the South and the Latitude of Kharga-Oasis in the North.Further North the series disappears beneath young and different cover formations;more fine=grained intercalations appear in that direction but,in the whole,there seems to be an inter-connection of water bearing layers.The sedimentary character of the facies has been described in detail lately by E.McKee (6).After the extremely irregular sedimentation of the very widespread formation it was warped,bent and broken within the regional tectonic frames of its area.The base of the complex rests on a pre-Nubian pene=plain in the South,on folded early paleozoic belts towards the North, both seem hydrologically tight.

The water in question seems to migrate within (mainly) this Nubian Se=ries.It appears in numerous wells,formerly in many open springs.This water has been investigated in a number of wells chemically and for its absolute age.We undertook the research in spite of the possibility that,such methods might render doubtful results.The water contains comparatively little dissolved matter,generally between 100 and 500 mg/l (compare Pavlov and Burdon 1959)(7)(8).Dr.Degens,in our investi=gations offered the opinion that these waters might be altered diage=netically i.e.influenced by the long-time-contact (exchange-reactions and the like) within the storage room.He furthermore gives a number of interesting ideas which cannot be quoted in detail but which will be available in a special publication in the Geol.Rdsch.in 1963 (9). Degens regards all the waters in question as exogene or phreatic,none of juvenile origin.That means that they must be derived from rains. Those rains apparently fell according to their $O^{18}/O^{16}$-ratio (Ep=stein 1959)(10) rather far from any sea,inland and at some distance from their infiltration area (Degens and Epstein 1961)(11).A comparison with the (Delta)$O^{18}$-values of the Nile River is possible and offers some analogies.Still,a direct connection with Nile water seems very unlikely.The infiltration areas should however be looked for within the dotted region of Figure I.

As far as the migration of the subsurface waters is concerned:The pre=sent temperature of the waters (28-40°Centigrade) points towards a circulation depth barely available in the South of the occurrences. Many of the artesian waters contain free gas.In 2 wells $CO_2$ was found, generally Nitrogene bubbles out of the wells in considerable amounts.

This Nitrogene might be a remainder of trapped porespace-air which has been robbed of its O- and C-content.Geologically(we shall see) this assumption fits into a possible story of the water itself.We know of similar occurrences in Australian artesian wells.
The $C^{14}$-age of the water was determined by K.O.Münnich of Heidelberg (9).Since according to the author mentioned (3) for age determination a certain carbonate content of the water is necessary,local assays were made and samples (up to 60 liters) were taken accordingly.A Tritium-check was made,Oxygen-isotope-tests have been mentioned already.Similar investigations were made with gastropode-shells contained in freshwater deposits normally connected with the oasis-depressions in question ( $C^{13}$and $O^{18}$)(Craig 1957)(12)(Epstein and others 1953)(13).

We came to the conclusion that,if the age obtained were correct, they would indicate an infiltration of the water about 25000-40000 years ago i.e. during the later stages of the Würm- (Wisconsinian-) glaciation.Probably prior to this Pluvial (or overlapping with it), the Mediterranean sea-level was at least 150 metres lower than it is to-day owing to the general eustatic situation.Consequently,the Nile River cut its bed to a level about 150-200 below its present bed.We know that from the Aswan-Highdam-investigations.Artesian waters still enter the Nile North of Aswan.At glacial times,huge quantities of the waters in question must have leaked out of the storage complex, whose pore-space has - in exchance - been filled by air.The Nitrogene mentioned above might be derived from it.
The Nile-leakage was sealed,when the Mediterranean rose again to its present level.Pluvial waters recharged the empty storage room in the mean time.
The infiltration area of the clastic beds must have been in the South (dotted area of Figure I.),the main storage - after the comparatively thin Nubian reservoirs in the Southern portion had dried out again - should be looked for in the Northern area,which is covered by younger formations (compare Ball 1900 a.o.,Hellstrøm 1940)(14)(1).A number of details which will be discussed elsewhere (9) point towards these conclusions.
The age obtained might be correct,it can however be a "mixed" age, consisting of several "Pluvials".It can indicate the age of a single water unit also.It gives no idea about the quantities to be expected (there are doubtless enormous quantities within the region).
We undertook the investigation as an experiment to be improved at the spot and,possibly,in similar semi-arid water-occurrences elsewhere.

## References (selected)


1. BALL, J., Kharga Oasis, Cairo (1900)
2. HEADNELL, H.J.L., Remarks on the prehistor. Geography etc. of Kharga Oasis. The Geogr. J. London 81 (1933)
3. BRINKMANN, R., K.O. MÜNNICH, J.C. VOGEL, $C^{14}$-Altersbestimmungen von Grundwasser. Naturw. 46, Gött. (1959)
4. KNETSCH, G. and M. YALLOUZE, Remarks on the origin of the Egypt. Oasis-depressions. Bull. Soc. Geogr. d'Egypte 28 (1955)
5. PFANNENSTIEL, M., Das Quartär d. Levante. II. Ak. W. u. Lit. Nr. 7, Mainz (1953)
6. McKEE, E.D., The Nubian Sandstone. Geol. Rdsch. (1963) (in press).
7. PAVLOV, M.J. and D.J. BURDON, Invest. and exploitation of groundwater for Kharga etc. Report to Gen. Des. Dev. Author. UAR, Cairo (1959)
8. PAVLOV, M.J., Groundwater of the Kharga Oasis etc. Rep. to Gen. Des. Dev. Authority. UAR, Cairo (1959)
9. DEGENS, E.T. in Knetsch, Degens, Münnich, Shata, Artesische Wässer in der östlichen Sahara. Geol. Rdsch. (1963) (in press)
10. EPSTEIN, S., The variation of the $O^{18}/O^{16}$ ratio in nature and some geol. implications. Res. in Geochemistry, edited by P.H. Abelson. J. Wiley and Sons, New York (1959)
11. DEGENS, E.T. and S. EPSTEIN, The relationship between the $O^{18}/O^{16}$-ratios in coexisting rocks. Typescript, in press
12. CRAIG, H., The geochemistry of stable carbon isotopes. Geochim. et Cosmochim. Acta 4, (1953).
13. EPSTEIN, S., R. BUCHSBAUM, H.A. LOWENSTAM, H.C. UREY, Revised carbonate water isotopic temperature scale. Bull. Geol. Soc. America. 64, (1953).
14. HELLSTRØM, B., The subterraneous water in the Libyan Desert. Bull. Nr. 26, Inst. of Hydraulics, Roy. Techn. Stockholm (1940)

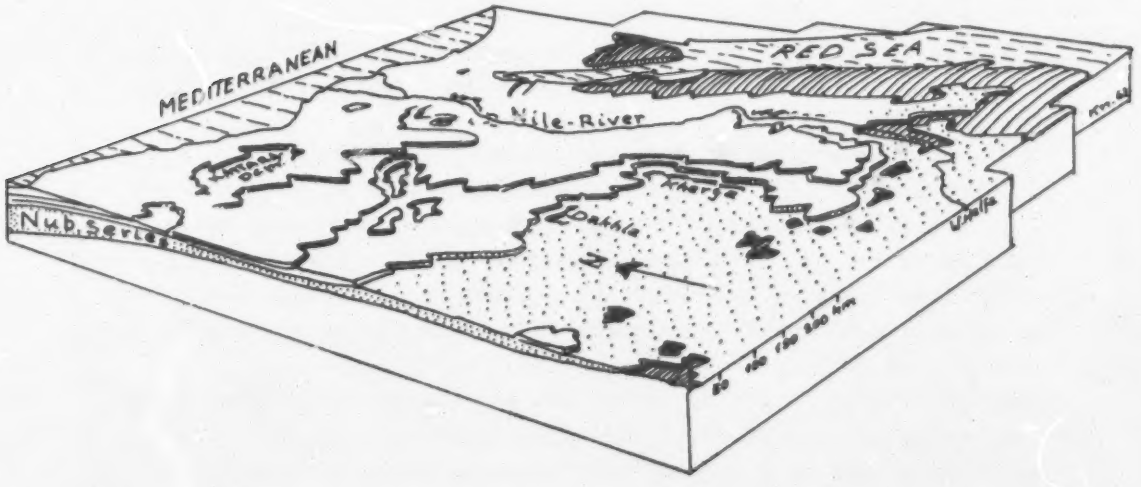




Figure I. Block-sketch of Egypt, seen from SW.
Dotted area: Nubian Series outcropping. Basement below, covering formations: U-Cretaceous and Tertiary.

1278 E - Nov. 1962 - 1,600